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An Investigation of the Impact of Requirements Engineering Skills on Project Success

Cynthia Atkins
East Tennessee State University

An Investigation of the Impact of Requirements Engineering Skills on Project Success

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Cynthia Atkins

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Dr. Tony Pittarese, Co-chair

Dr. Phil Pfeiffer, Co-chair

Dr. Chris Wallace

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ABSTRACT

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A survey of project managers and requirements engineers was conducted to determine what skills, qualifications, and experiences were associated with project success. Survey results indicated that projects using Joint Application Development (JAD) sessions, use cases, and prototypes to engineer requirements were most successful. Other indicators of project success, according to participants, included an adequate allotment of time for requirements engineering—at least 15% of a project's time—and the use of project managers and requirements engineers with professional work experience. In particular, data indicated that Project Managers with at least five years of experience in Information Technology resulted in more successful projects.

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CHAPTER 1
INTRODUCTION

A project is an effort with a beginning and an end that will deliver something new to an organization. (PMBOK, 2008) Projects are the mechanisms that organizations use to implement strategies. (Crowe, 2006) They are essential to an organization's survival due to the ongoing need for innovation and change. (Shenhar, 2007)

A project is often considered to be successful if its developers complete it within the allocated budget, deliver it on time, and meet the "real" requirements of the organization that commissioned it. (cf. Berntsson, 2006) As a rule, project's requirements—i.e., its deliverables, goals, and expectations—must be clearly and correctly defined in order for it to succeed. The root cause of failures for Information Technology projects can often be traced to faulty requirements. Faulty requirements can lead to software defects (Wiegers, 2003), insufficient or incorrect functionality, increased costs (Katonya, 2003), customer dissatisfaction, and even total project failure (Leffingwell, 2003). According to Wiegers, requirements errors cause 40% to 60% of all defects in software projects. (Wiegers, 2003) About 25% of respondents to the 1999 Standish Group "Chaos" survey identified errors in requirements as the primary cause of missed deadlines. (Standish, 1999) In addition, faulty requirements increase project costs increased due to the need to rework artifacts that have been designed, implemented, and possibly even tested. (McConnell, 1998) Faulty requirements may also lead to a project not meeting user needs or expectations—a primary reason for a project's being declared a failure.

Gathering sound requirements has long been known to be a difficult problem. As Frederick Brooks has noted, "The hardest part of the software task is arriving at a complete and consistent specification." (Brooks, 2003) "Requirements", notes McConnell, "are not 'out there' in the users' minds waiting to be gathered in the same way that iron ore is in the ground waiting to be mined. Users' minds are fertile sources of requirements, but the project team must plant the seeds and cultivate them before the requirements can be harvested." (McConnell, 1997)

Various authorities have emphasized the importance to a project's success of using qualified staff to gather requirements. (Wiegers, 2003) “Empirical studies suggest that competent staff with adequate technical skills can plan an important role in facilitating positive project outcomes.” (McLeod, 2011) Those who will engineer requirements must be carefully selected and receive appropriate training to provide high quality requirements and ensure project success. “A skilled and competent project team was considered to be more able to identify the complex project requirements.” (McLeod, 2011) Finally, the Standish group has estimated that placing more emphasis on requirements engineer selection could eliminate as much as 25% of failed projects. (Standish, 1999)

This research sought to identify those qualifications, skills, and experiences in requirements engineering that best correlate with project success. The vehicle for the research was a survey that asked participants to characterize specific projects they had done and the skills of those who worked on those projects. This survey was circulated among practicing project managers and requirements engineers. Project managers were asked about the skills, qualifications, and level of experience of those who served with them as requirements engineers. Requirements engineers were also asked about their own skills, qualifications, and level of experience. All were asked about specific projects and the success of those projects. Requests to participate in the survey were sent through selected chapters of the Project Management Institute (PMI), project management groups and business analysis groups on LinkedIn, and e-mails to professional contacts. A total of 116 project managers and requirements engineers participated in the survey. Project success and the skills, qualifications, and levels of experience were then compared to determine which of these qualities best correlated with project success.

The survey identified several items as having a significant impact on project success. Projects that used Joint Application Development (JAD) sessions, use cases, and prototypes for requirements engineering were the most successful. Projects succeeded if the requirements engineer felt the time planned for requirements engineering for the project was adequate. Individuals with more professional work experience had more successful projects. Project managers with at least five years of Information

Technology experience were the most successful. When 15% or more of the total project time was devoted to requirements engineering, projects were more successful.

The survey also yielded a profile of qualified candidates for the role of requirements engineer. These candidates will have a bachelor's degree in Computer and Information Science. They will have at least five years of professional experience. Those candidates with greater professional experience and greater experience in Information Technology would be best. They will have served in the project manager, business analyst, or software engineer role. They will have at least one professional certification such as Project Management Professional (PMP), Certified Business Analysis Professional (CBAP), or Certified Software Quality Engineer (CSQE). They should be familiar with Rapid Application Development, Joint Application Development (JAD) sessions, use cases, and prototypes and preferably have experience using each of these. When the project is executing, they should be given at least 15% of the project time to develop requirements, or more if they feel this is needed. They should also select and follow a standard for requirements for the project. They should have strong communication skills and help the customer and project team to collaborate.

For prospective requirements engineers who lack these skills, organizations should provide support and training in these areas. Those who do not have a bachelor's in Computer and Information Sciences should be encouraged to seek this education and support if possible. They should be provided with opportunities to work with someone who does have these experiences and, ideally, is actively serving as a requirements engineer. Organizations should also encourage continued learning and professional certification. Any education or training pertaining to Rapid Prototyping, JAD sessions, and use cases will be most helpful. This provides guidance to those who wish to move into the requirements engineering role so that they can be most effective and fully prepared for the position.

These results, while suggestive, should be viewed in terms of the survey's limitations. Participation was voluntary; participants, who were self-selected, provided information on projects of their own choosing. It was not possible to define the population of project managers in Information Technology or practicing business analysis, requirements analysts, and requirements engineers so that a random sample could be selected for the survey. Only those individuals who could be contacted through selected PMI chapters, selected LinkedIn groups, and e-mail contact participated; this is almost surely a small set of the total population of project managers and requirements engineers. The survey was also limited to those who are currently serving in a project management or requirements engineering role. Potential participants who had previously served as a project manager or requirements engineer were excluded because there was no way to identify these individuals or contact them. The survey was also open for only a few months. More project information might be collected by opening a survey and leaving it open for an extended period of time to collect project information as projects open and close. All respondents provided information about one project, although it was possible for them to submit information about multiple projects. Respondents could ask questions about the survey, but there was no way to offer assistance while the survey was being completed. Some areas where results were inconclusive include whether participating in more projects increases success, whether a project manager holding a project management degree increases success, and whether facilitation or negotiation training or experience increases success.

CHAPTER 2

BACKGROUND

Projects and Success

A project is defined by the Project Management Institute (PMI) as, “a temporary endeavor undertaken to create a unique product, service, or result.” (PMBOK, 2008) A project has a start date, finish date, and will generate something new to the organization. Projects are not the day-to-day work people do, but instruments to accomplish a strategy.

Projects must succeed in order for an organization to meet its goals; they turn strategies into tangible results. (Crowe, 2006) Projects drive innovation and change. As Shenhar notes, “No business enterprise can survive if it is focused only on improving its operations. The next untapped candidate for significant improvements in a company’s pursuit of competitiveness is the project activity of the organization.” (Shenhar, 2007) Projects should align with the organization’s strategic intentions and help the organization meet goals set forth by management. (Rosenau, 2005) If projects fail, the results are never realized, and organizations will not meet their goals or fulfill their strategies.

There is no one standard definition for project success. (O'Brachta, 2001; Shenhar, 2007) “Identifying just what constitutes success or failure, however, can be problematic. In general, there remains a lack of consensus on how to define success, lack of success, and failure.” (McLeod, 2011) The most common criteria involve a balance of project budget, schedule, and requirements – often referred to as the “triple constraint” due to their interdependence. (Berntsson, 2006) A project that is completed within the allocated budget, on time, and that meets its requirements is often considered to be successful. (Berntsson, 2006) Other determinants of project success may include business objectives, stakeholder perspectives, product success factors, performance requirements, and user acceptance. Even this list is not exhaustive. As Berntsson notes, “projects that meet all of these factors are not necessarily viewed as successful. On the other hand, there are projects that do not meet the above criteria, but are considered successful nonetheless.” (Berntsson, 2006). Since what constitutes success is specific to each project, a project's manager should make sure these are defined very early in a project's life to ensure the goals are met at a project's conclusion. (O'Brachta, 2001)

Project Success and Requirements Quality

A project's requirements define what is needed to change from the current state to some future state. "From a customer's point of view, the requirements stage is necessary because it helps to understand the new needs and to identify how they can be satisfied." (Macaulay, 1996)

A problem in the requirements can directly impact project success. According to Taylor (2008), "More than half the errors in a project originate with the requirements and analysis activities done prior to product design. Most projects fail as a result of incomplete requirements, poorly written requirements, or misinterpreted requirements." Of project failures, 24% were attributed to incomplete requirements and specifications or changing requirements. "It seems clear that requirements deserve their place as a leading root cause of software problems, and our continuing personal experiences support that conclusion." (Leffingwell, 2003)

Problems with requirements can have an adverse impact on the overall project. "Errors made during the requirements stage account for 40 to 60% of all defects found in software projects." (Wiegers, 2003) While various authorities cite different estimates of the impact of requirements errors on project cost, the consensus is that requirements errors are among the most costly to fix. "Given the frequency of requirements errors and the multiplicative effect of the "cost to fix" factor, it's easy to predict that requirements errors will contribute the majority—often 70% or more—of the rework costs. Since rework typically consumes 30% to 50% of a typical project budget [Boehm and Papaccio 1988], it follows that requirements errors could consume 25% to 40% of the total project budget!" (Leffingwell, 2003) McConnell (1998), citing data from Boehm, notes that "For each requirement that is incorrectly specified, you will pay 50 to 200 times as much to correct the mistake downstream — during coding — as you would pay to correct the mistake at requirements time." Katonya and McConnell, among others, note that these increased costs were due to the fact that requirements errors potentially affect all phases of the software development life cycle:

> *Fixing requirements problems may require rework of the system design, implementation, and testing. Consequently, the costs are high.* (Katonya, 2003)
>
> *One sentence in a requirements specification can easily turn into several design diagrams. Later in the project, those diagrams can turn into hundreds of lines of source code, dozens of test cases, many pages of end-user documentation, help screens, instructions for technical support personnel, and so on. If the project team has an opportunity to correct a mistake at requirements time when the only work that has been done is the creation of a one-sentence requirements statement, it makes good sense for the team to correct that statement rather than to correct all the various manifestations of the inadequate requirements statement downstream.* (McConnell, 1998)

These corrections, if not anticipated in a system's original estimate, can lead to delayed delivery and cost overruns. "Shortcomings in requirements practices pose many risks to project success, where success means delivering a product that satisfied the user's functional and quality expectations at agreed-on cost and schedule." (Wiegers, 2003)

Without accurate requirements, a project may encounter various problems. If a project's requirements provide an incorrect characterization of a project's scope, its project plan, including budget and schedule estimates, will have been developed from incorrect definitions. Another problem is that errors in requirements tend to grow and take more effort to correct the later in the project lifecycle that they are discovered. More effort will be needed to correct the error, leading to increased costs and a longer schedule. A third problem is that incorrect requirements can yield products that fail to meet users' needs or gain their acceptance. This may also mean that business objectives have not been met.

Overview of Requirements Engineering

The Software Engineering Body of Knowledge (SWEBOK) describes requirements development as a "fundamentally interdisciplinary" process that is managed by requirements specialists who mediate between a project's stakeholders, including its users, operators, and customers, and its software engineers." (SWEBOK, 2004) According to Macaulay, this process, known as requirements engineering, "is concerned with finding out about the future situation and the associated change … with gathering information and considering possible options, and with identifying what should be designed in order to meet some perceived future need." (Macaulay, 1996)

Requirements engineers work with clients to discover what clients require and communicate those needs to team members that will develop the final product. (Schach, 1996) They also advocate for those users and document the requirements. (Henry, 2003) "Our challenge is to understand users' problems in their culture and their language and to build systems that meet their needs." (Leffingwell, 2003)

Requirements engineering is typically a complex and challenging activity. Hoffman, for example, states requirements engineering, "is deficient in more than 75% of all enterprises." (Hoffman, 2001) A variety of techniques may be needed for requirements engineering and they may be applied differently depending on the situation. (Robertson, 2006) "Thus, Requirements Engineering and the Requirements Engineering process are to some extent situation dependent. Indeed, this is one of the reasons why it is difficult to define the tasks of the Requirements Engineer." (Macaulay, 1996)

A skilled requirements engineer (RE) must address a variety of issues to succeed. An RE must have strong communication skills. "Requirements come from humans, so the better you are at interacting with humans, the better you will be at gathering requirements." (Robertson, 2006) REs must communicate with all key sources of requirements. "If they don't identify all of the stakeholders, the requirements analyst won't find all of the requirements." (Robertson, 2006) REs must account for influences on requirements that originate from sources other than stakeholders. Macaulay quoting Bubenko states, "most of the problems in system development have their roots not just in technical (software) issues but also in managerial, organizational, economical, and social issues." (Macaulay, 1996) Requirements elicitation may also be affected by misconceptions as to what a system can or should do. Pressman, citing Christel and Kang (1992), states requirements elicitation is difficult because a system's boundary – its scope – is ill-defined or confusing; because customers are unsure what is needed or the technical capabilities and limitations of their computing environment; and because requirements change over time. (Pressman, 2001)

Authorities cite requirements-related reasons for systems failure that include the lack of a systematic requirements engineering process, overlooked users, insufficient user involvement, poor communication between people, poor management of people and resources, lack of appropriate knowledge or shared understanding, and inappropriate, incomplete, incorrect, or ambiguous documentation. (Macaulay, 1996; Wiegers, 2003) According to Leffingwell, "Lack of user input, incomplete requirements and specifications, and changing requirements and specifications are commonly cited problems in projects that failed to meet their objectives." (Leffingwell, 2003) In a survey of case studies and literature, McLeod identified a lack of well-defined project goals, inadequate time allocated to requirements, poorly defined or unstable requirements, and developers' lack of understanding of users' needs or work as negative impacts on project success. (McLeod, 2011)

Two contrasting strategies have been proposed for requirements development. In the first, members of software development teams serve as requirements engineers. Pressman, for example, describes the requirements elicitation process as, "ask[ing] the customer, the users, and others what the objectives for the system or product are, what is to be accomplished, how the system or product fits into the needs of the business, and finally how the system or product is to be used on a day-to-day basis." (Pressman, 2001) He adds that "systems engineers must approach the requirements gathering in an organized manner," further implying that requirements engineering is the responsibility of system engineers, as opposed to customers, users, or other stakeholders. (Pressman, 2001) Similarly, Kotonya and Sommerville describe requirements elicitation as a process where "system developers and engineers work with customers and end-users to find out about the problem to be solved, the system services, the required performance of the system, hardware constraints, and so on." (Kotonya, 1998) Again, Robertson argues that "The lead requirements analyst coordinates the group as they come to a consensus on what the scope of the work is—that is, the business area to be studied—and how this work relates to the world around it." (Robertson, 2004)

The other strategy for requirements engineering makes the customer responsible for providing requirements. According to Taylor, "The customer defines requirements. That is, the customer, whether internal to an organization or external, desires a product or service to meet some need and then communicates this need to the provider." (Taylor, 2008) This second strategy places the burden of discovering and documenting requirements on the project's customers or end-users, people who may not have any experience with software development or training in Information Technology.

These two views describe requirements engineers with very different backgrounds. A study on requirements engineering processes and their connection to project success found that the requirements engineering team needed in-depth knowledge of both the application domain and Information Technology—a finding that would support the use of requirements specialists for requirements engineering. This study, however, did not attempt to correlate educational background or work experience with project success. (Hoffman, 2001)

Requirements Engineering: Best Practices

Research has been conducted to determine which requirements engineering practices contribute to project success. Hoffman determined that the most successful projects had skilled project managers and team members assigned to requirements engineering tasks. According to Hoffman, requirements engineering efforts need 15% to 30% of overall project time. Hoffman identified the following as best practices for group management: involving customers and users throughout the requirements engineering process, identifying and consulting all likely sources of requirements, maintaining good relationships among stakeholders, using specification templates and examples, developing complementary models and prototypes, maintaining a traceability matrix, and using peer reviews, scenarios, and walk-throughs to validate and verify requirements. (Hoffman, 2001) Best practices for requirements engineering are also defined within the Software Engineering Body of Knowledge (SWEBOK, 2004) produced by Institute of Electrical and Electronics Engineers (IEEE). These include identifying stakeholders or actors in the requirements, eliciting and validating requirements using prototypes, scenarios or use cases, and models, negotiating which requirements to include in the scope of the project, analyzing the requirements against any constraints, prioritizing requirements in terms of importance, and identifying components or sub-systems within the requirements. (SWEBOK, 2004)

Requirements Engineering: Key Skills

Various authorities have argued that effective requirements engineering involves specialized skills and training. "It isn't reasonable to expect people to serve as analysts without sufficient training, guidance, and experience. They won't do a good job and they'll find the experience frustrating." (Wiegers, 2003) These authorities have also produced various recommendations for skills that requirements engineers ought to have:

- A 1995 survey of 32 companies by Macaulay identified eight desirable skills for requirements engineers. (Macaulay, 1996) Table 1 lists these skills or qualities.

Table 1 Requirements Engineering Skills/Qualities Identified by Macaulay

	Author
Skills/Qualities	Macaulay
Interviewing	✓
Groupwork	✓
Facilitation	✓
Negotiation	✓
Analysis	✓
Problem Solving	✓
Presentation	✓
Modeling	✓

- Wiegers (2003) identifies 10 essential skills for requirements engineers. These skills include interviewing and questioning, interpersonal skills, facilitation skills, analytical ability, creativity, modeling, observational skills, writing ability, organizational skills, and listening. Wiegers recommends these skills based on his own experiences as well as other published sources. These various recommendations for requirements-related skills, though similar, are not quite identical. Wiegers, for example, differs from Macaulay in two regards, as shown by Table 2.

Table 2 Requirements Engineering Skills/Qualities Identified by Macaulay and Wiegers

Skills/Qualities	Authors	
	Macaulay	Wiegers
Interviewing, Questioning, Observing	✓	✓
Groupwork, Interpersonal	✓	✓
Facilitation	✓	✓
Negotiation	✓	
Analysis / Analytical	✓	✓
Problem Solving, Creativity	✓	✓
Presentation, Writing, Listening	✓	✓
Modeling	✓	✓
Organizational		✓

- The International Institute of Business Analysts (IIBA) publishes a standard for business analysis processes called the Business Analysis Body of Knowledge (BABOK). This standard was developed to be industry agnostic and can be applied to any type of project, including requirements engineering. A set of underlying competencies was identified for Business Analysts using this standard. These competencies include communication skills, group interaction skills, analytical thinking and problem solving, behavioral characteristics (such as ethics, trustworthiness, and personal organization), business knowledge, and software applications, including modeling tools, word processing, and requirements management tools. BABOK, though similar to the previous authors, uses broader categories, as shown in Table 3.

Table 3 Requirements Engineering Skills/Qualities Identified by Macaulay, Wiegers, and BABOK

Skills/Qualities	Authors		
	Macaulay	Wiegers	BABOK
Communication skills - Presentation, Writing, Listening, Interviewing, Questioning, Observing	✓	✓	✓
Group Interaction skills - Groupwork, Interpersonal	✓	✓	✓
Facilitation	✓	✓	
Negotiation	✓		
Analysis / Analytical	✓	✓	✓
Problem Solving, Creativity	✓	✓	✓
Software Applications – Modeling tools, Word Processing, Requirements Management tools	✓	✓	✓
Behavioral Characteristics – Organization, Ethics, Trustworthy		✓	✓
Business Knowledge			✓

- In a survey of project managers by Vale (2010), respondents identified the following as the most "relevant" skills for requirements engineering: oral and written communication, facilitation, ethics, and orientation to customer needs. Table 4 presents a final comparison between Macaulay, Wiegers, BABOK, and Vale.

Table 4 Requirements Engineering Skills/Qualities Identified by Macaulay, Wiegers, BABOK, and Vale

Skills/Qualities	Authors			
	Macaulay	Wiegers	BABOK	Vale
Communication skills - Presentation, Writing, Listening, Interviewing, Questioning, Observing	✓	✓	✓	✓
Group Interaction skills - Groupwork, Interpersonal	✓	✓	✓	
Facilitation	✓	✓		✓
Negotiation	✓			
Analysis / Analytical	✓	✓	✓	
Problem Solving, Creativity	✓	✓	✓	
Software Applications – Modeling tools, Word Processing, Requirements Management tools	✓	✓	✓	
Behavioral Characteristics – Organization, Ethics, Trustworthy		✓	✓	✓
Business Knowledge			✓	✓

The one skill or quality cited by all sources is communication. McLeod also found in their survey of sources that, “good interpersonal and communication skills are perceived to be important for interacting with users, and for facilitating dialogue between different groups of users,” and that better communication skills led to increased user satisfaction with the final product. (McLeod, 2011) Macaulay, Wiegers, BABOK, and Vale address communication in different ways. Some mentioned specific forms of communication such as Presentation. BABOK brought these skills together under one category with the competency of Communication skills. Strong communication skills are recommended universally.

Certifications Related to Requirements Engineering

Certifications have value because they attest to a level of competency in a particular field. While there are currently no certifications in requirements engineering proper, various organizations offer certifications in project-related competencies like project management and business analysis that include requirements engineering as one of their competencies.

There are several certifications related to project management. The Project Management Institute (PMI) offers Project Management Professional (PMP®) certification. “The PMP® demonstrates that you have the experience, education and competency to successfully lead and direct projects.” (PMP, 2011) PMI also offers Certified Associate of Project Management (CAPM) which does not require any project management experience, but demonstrates an individual understands the fundamentals of project management. In addition, PMI offers Program Management Professional (PgMP) certification for those who manage programs: i.e., “group(s) of related projects managed in a coordinated way to obtain benefits and control not available from managing them individually.” (PMI-Program, 2008) Other project-management-related certifications offered by the PMI include certifications in risk management (PMI-RMP), project scheduling (PMI-SP), and PMI's Organizational Project Management Maturity Model (OPM3) certification, a competency that involves the linking of “project, program and portfolio management to strategy" in ways that "achieve better performance, better results and a sustainable competitive advantage.” (OPM3, 2011)

Other project management certifications are offered by the IMPA and the APM. The Netherlands-based International Project Management Association (IPMA) offers project management certifications similar to CAPM, PMP, PgMP, and OPM3. The PRINCE2 project management certification is endorsed by the United Kingdom as a project management standard and is maintained by the Association for Project Management (APM).

The IIBA certifies business analysts. “Business analysis is the set of tasks and techniques used to work as a liaison among stakeholders in order to understand the structure, policies, and operations of an organization, and recommend solutions that enable the organization to achieve its goals.” (BABOK, 2008) BABOK, a standard developed by IIBA, discusses in detail how to obtain and management requirements for any project. BABOK can be applied to any project and is not specific to Information Technology. CBAP is directed towards “senior business analysts who have the skill and expertise to perform BA work on projects of various sizes and complexities.” CBAP requires years of experience, a concentration in a specific area of business analysis, a demonstration of continued learning, and recommendations from colleagues familiar with the individual’s business analysis skills. Additionally, individuals must pass an examination to demonstrate their competency in BABOK (IIBA, 2011). Having this certification proves that an individual understands how to gather, document, and manage a project's requirements.

The International Association of Facilitators (IAF) offers the Certified Professional Facilitator certification. This certification attests to a person's skill in planning group processes such as meetings and creating and sustaining a participatory environment (IAF, 2011).

The Object Modeling Group maintains the Unified Modeling Language (UML) standard and offers a certification that attests to an individual's understanding of the standard. Three exams comprise the certification and each examination proves a different level of expertise with UML. Someone with these certifications has the knowledge and skills to carry out modeling for the requirements engineering tasks on a project.

The American Society for Quality (ASQ) offers a Software Quality Engineer Certification. Recipients must demonstrate a thorough knowledge of the Software Quality Engineer Body of Knowledge maintained by ASQ. Recipients must also have eight years of software quality engineering experience. Portions of this experience may be fulfilled by educational experience, such as a bachelor's or a master's degree. Having this certification can ensure a project will be able to deliver a quality product.

CHAPTER 3
RESEARCH PLAN
Purpose

Project failure rates are high among Information Technology (IT) projects. (Standish, 1999) The majority of IT projects fail. Compared with other industries, Information Technology project success rates are much lower. (Crowe, 2006) Among these failures, a significant number are due to problems that can be traced back to the requirements. (Wiegers, 2003) By examining successful projects, it may be possible to discover what skills, qualifications, and experiences those who worked on requirements possessed. By identifying these qualities, it would be possible to understand what to look for when staffing a project. It would also be possible to provide the training and career path to employees to help them to be most effective on projects. A survey of project managers and requirements engineers was conducted to determine what skills, qualifications, or experiences correlate with project success.

Studies have been conducted to identify trends in project management and requirements engineering. These studies have attempted to correlate a software project's degree of success with the skills, experience levels, and qualifications of its developers. These studies have not, however, attempted to correlate a project's degree of success with the skills of its managers. Studies of best practices and requirements engineering skills, moreover, have failed to correlate these practices with the skills are required to support those practices.

This research sought to use a survey of project managers and requirements engineers that asked about their skills, professional certifications, years of experience, and project outcomes to identify the requirements engineering skills that are most present in successful projects. A professional with these skills may be able to provide a better set of requirements and therefore increase the likelihood for project success. Ensuring those who serve in the requirements engineer role have received training related to these skills may increase overall project success rates.

Methodology

An online survey was used to obtain information on participants' professional qualifications and their roles in and experiences with software project development. The survey, which was directed to project managers and requirements engineers, asked participants which designation best characterized their duties as a software professional. Depending upon the response, respondents were given one of two sets of questions. One, for project managers (Appendix A), focused on participants' project(s) and the team member(s) on their project(s) who worked on requirements analysis The other, for requirements engineers (Appendix B), focused on the individual respondent and his or her own personal skills, qualifications, and experiences and about the success of their projects.

The survey questions for project managers were numbered sequentially and each number prefaced with “PM.” The survey questions for the requirements engineers were numbered sequentially and each number prefaced with “RE.” This numbering makes it clear which questions from which survey were being included in any particular analysis point.

Each respondent was asked to complete two sections of questions. The first section contained questions about skills, qualifications, and experience which were not specific to a particular project. For example, respondents were asked how many years of professional experience they had which would not vary with each project. The second section contained project-specific questions concerning topics like as the project's success and what methodologies were used.

The survey for project managers involved 10 questions about the project manager’s experiences and qualifications and 23 questions about each project. The survey for requirements engineers involved 13 questions about their experiences and qualifications and 19 questions about each project. Respondents were required to provide project experience information for at least one project, and offered the chance to submit information for about up to 10 different projects.

This survey was posted online using www.surveymonkey.com. SurveyMonkey, a commercial web-based survey tool, was chosen because it supported the development of questionnaires that branched based on user responses to questions.

Target Audience

This survey was directed towards project managers and requirements engineers. Two of the leading organizations related to these professions are PMI and IIBA. Research was conducted by contacting these organizations' chapters, posting survey information on social media sites, and sending requests to professional contacts.

The survey was promoted in several ways. Details about the survey were e-mailed to PMI chapters in the southeast. The chapter leadership was asked to forward this information to their members and affiliates. Additionally, members and affiliates were asked to forward this information to their professional contacts who are active project managers and requirements engineers. The researcher already had a relationship with PMI and had connections with some of the PMI chapters. The researcher forged new connections with other PMI chapters to try and reach as many people as possible.

Many PMI chapters maintain a presence on LinkedIn (www.linkedin.com), a social networking site focused on professional connections. Links and requests to complete the survey were also posted on these LinkedIn PMI chapter sites. These requests were posted to PMI chapters with larger participation in LinkedIn and included such geographic areas as Washington, D.C., Southern Florida, Atlanta, Dallas/Fort Worth, and Los Angeles. The researcher, who was a member of LinkedIn, obtained permission to participate in the PMI chapter sites in order to post information about the survey.

Chapters of the IIBA also maintain a presence on LinkedIn. Requests to complete the survey were posted to these IIBA chapter sites. This allowed the researcher to contact requirements engineers as well as project managers.

LinkedIn hosts several groups that are related to project management and requirements engineering that have no direct connection to professional societies. Requests to participate in the survey were posted to these groups as well.

Finally, requests were e-mailed to professional contacts to complete the survey. It was also requested they pass the survey along to other professional contacts that might have Project Management or requirements engineering experience.

It was expected that each respondent would take the survey only once; however, no measures were taken to ensure this. In addition, information provided in the survey was assumed to be true and accurate to the best of the respondent's knowledge. Finally, participation in the survey was completely voluntary.

Site administrators have access to the survey data; however, no identifying information was collected from respondents. This information was aggregated to identify correlations and individual cases were not reviewed or examined.

Participants

This survey, which was active from August 1, 2011 through October 31, 2011, was completed by 116 people. Of the respondents, 60 (51.7%) identified themselves as project managers while 56 (48.3%) identified themselves as requirement engineers. These categories are somewhat nebulous, since there are no standard definitions of the roles of project manager or requirements engineer in Information Technology; no known directory or census with this information; and no clear separation of these roles among professionals who may serve in multiple roles on the same project. (McLeod, 2011) Figure 1 provides a graph of the responses by role.

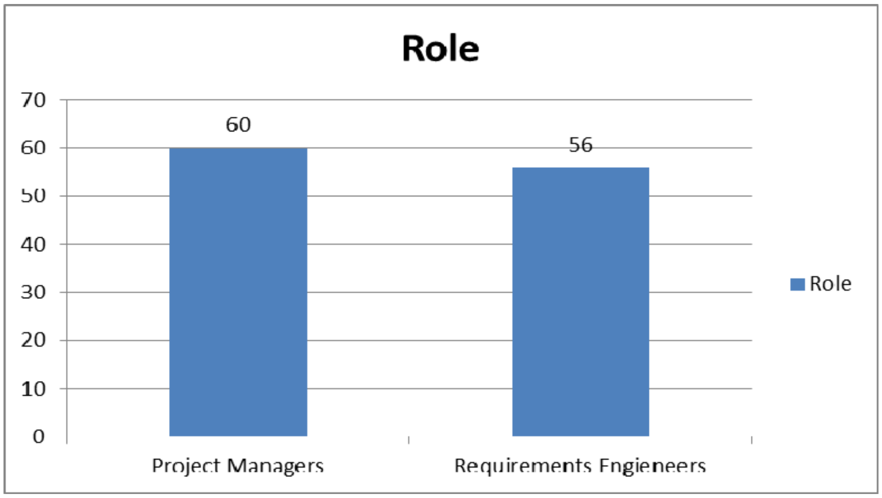

Figure 1 Number of Responses from Project Managers and Requirements Engineers

Of the respondents, 27 (23.3%) answered questions related to their own skills, qualifications, and experiences, but failed to provide information about a particular project. Eighty-nine (76.7%) of the respondents completed the entire survey. Each provided information for exactly one project. Figure 2 is a graph of the responses with and without project information.

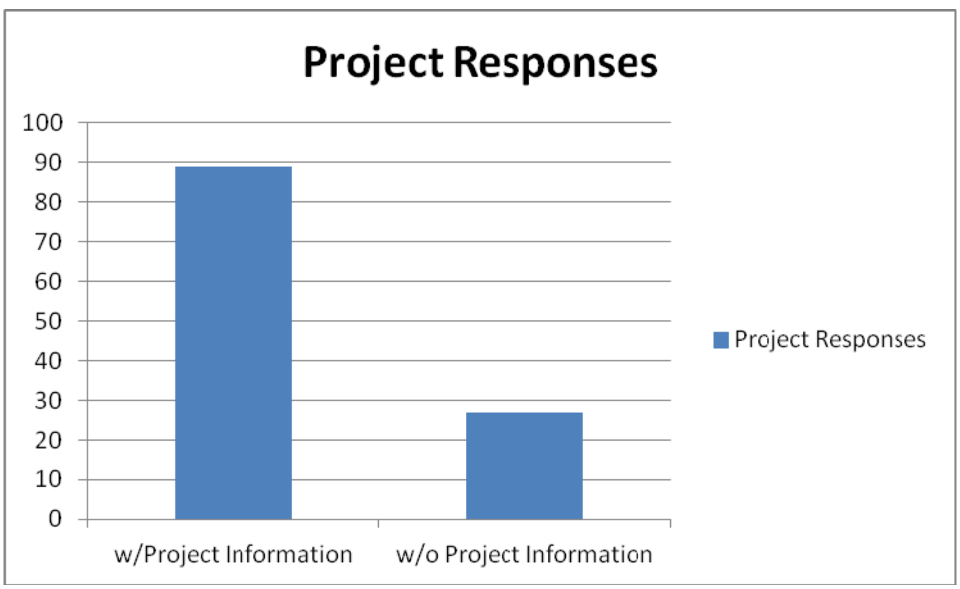

Figure 2 Number of Responses With or Without Project Information

Respondents' skills, qualifications, and experiences were compared against their reported project successes in order to determine if any particular characteristics were more prevalent in successful projects. Respondents were asked to rate project success on a scale of 1 to 10 with 10 being the most successful. Figure 3 illustrates the distribution of success rating among the responses by number. Figure 4 shows the percentage of projects in each success rating level.

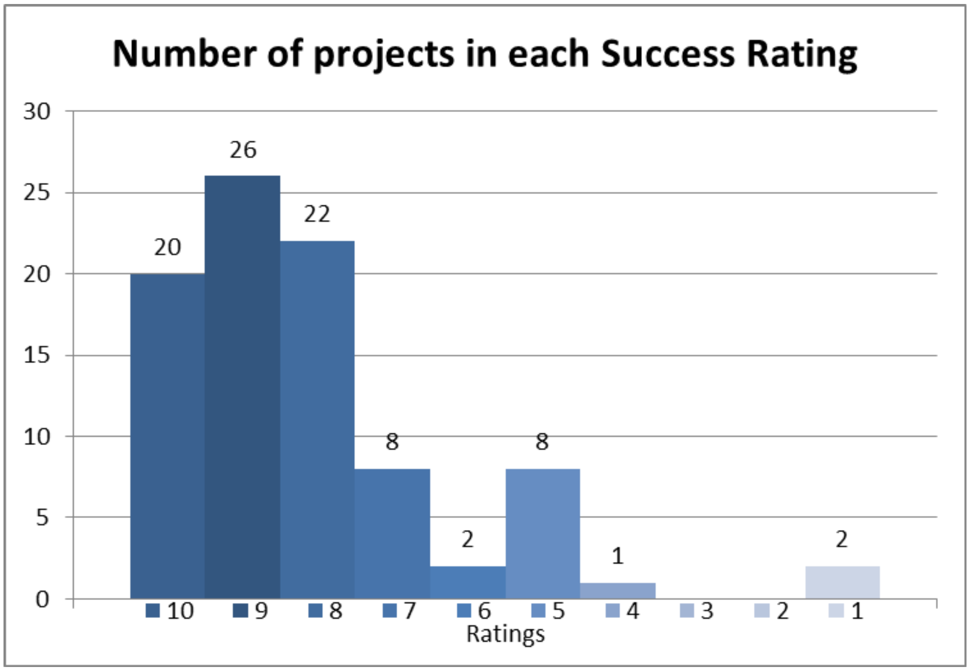

Figure 3 Distribution of Projects in Success Ratings

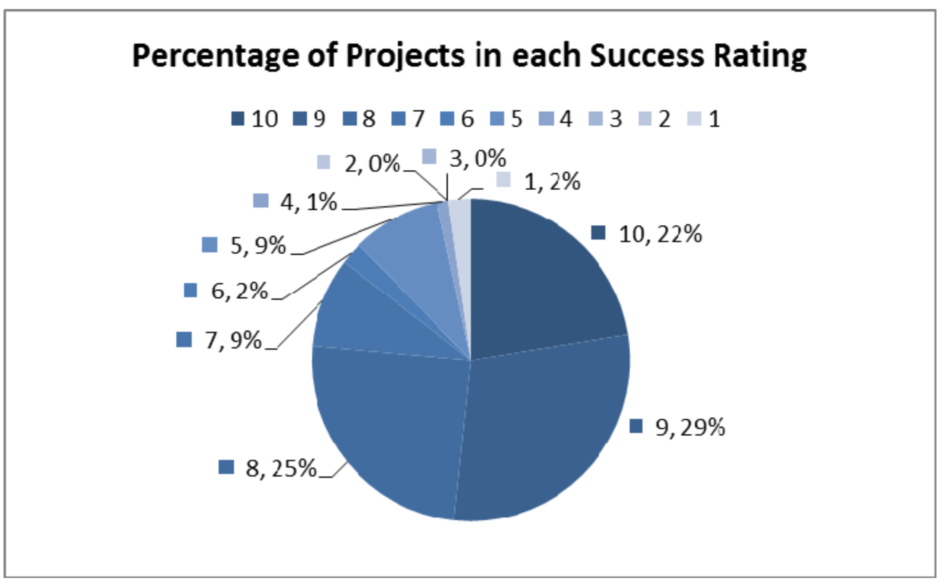

Figure 4 Percentage of Projects in Each Rating

Those projects rated as 8, 9, or 10 were categorized as successful. Significantly fewer projects were rated below 8. For this reason, 8, 9, and 10 were categorized as successful. All others were categorizes as failure. Figure 5 shows the distrbution of projects within the success and failure categories.

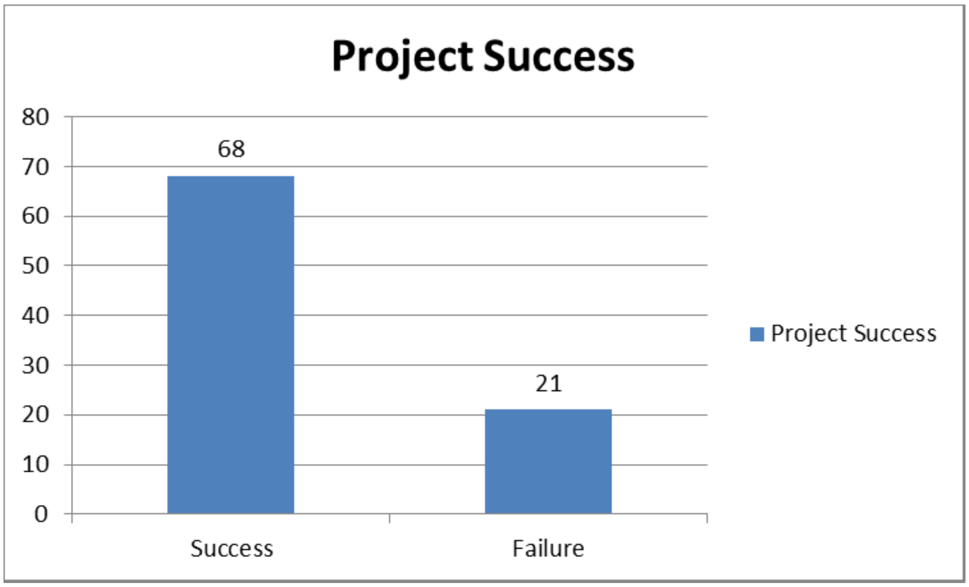

Figure 5 Number of Projects Rated as Successes or Failures

Of the 89 projects that were submitted, 68 were rated as an 8, 9, or 10 and therefore categorized as successful. Within these responses, projects succeeded 76% of the time (see Appendix C for full analysis of project success). Figure 6 shows the percentage of projects categorized as success and failure.

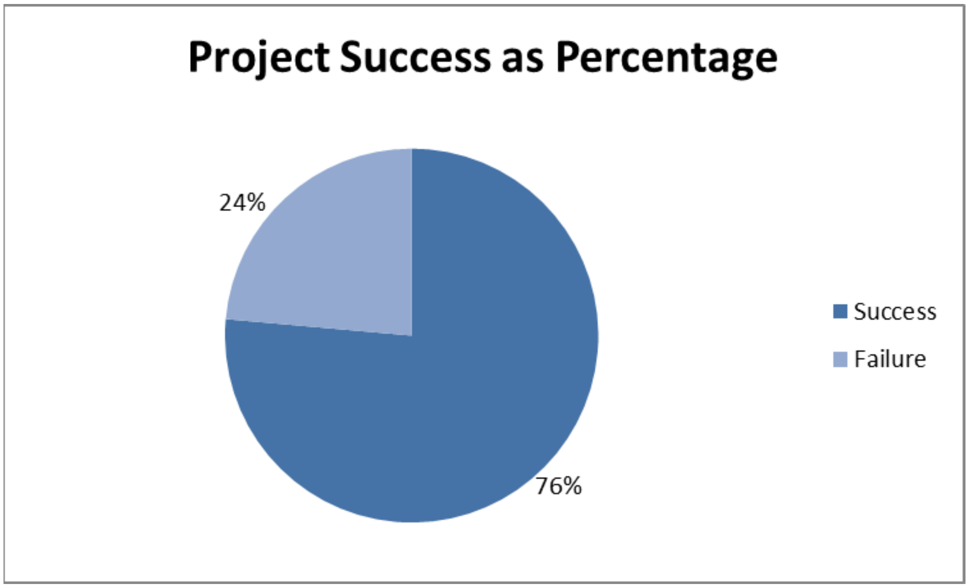

Figure 6 Percentage of Project Successes or Failures

Survey Collection, Coding and Analysis

During the collection of survey data, no administration problems were encountered nor were there any significant questions raised while the survey was active. Since this was an online survey, most responses were constrained so that the respondent could only make valid choices. As skills, qualifications, and experiences were compared against project success, only those responses that included project information were included in the analysis.

Survey response data was coded into SPSS Statistics 20.0 for data analysis and reporting. The results of the data analysis are presented in the following sections.

CHAPTER 4
ANALYSIS AND DISCUSSION

Respondents were asked about their own experience, skills, and qualifications. They were also asked for details about specific projects. These were related to project success rating to determine what might improve project success rates. Respondents were asked to rate individual project success on a scale of 1 to 10 with 10 being the most successful. All projects rated less than 8were categorized as failure (see appendix C for more information on the project success responses from the survey). The median rating for project success was 9 and 76.4% of projects were rated as 8, 9, or 10.

Chi-square tests were used to determine which qualities of a project and the respondent may have influenced its success. Those qualities with a p-value of 0.05 or less were considered conclusive; these qualities do have an impact on project success. Those qualities with a p-value between 0.06 and 0.1 were considered suggestive; there is a strong possibility the quality impacts project success, but it cannot be determined absolutely. P-values greater than 0.1 were considered as inconclusive; i.e., as qualities that do not necessarily impact project success.

<u>PM1 / RE1: How many years have you been in the professional work force?</u>

All respondents were asked how many years of experience they have in the professional work force. This typically begins after the completion of secondary or post-secondary education. The years of experience were divided into five ranges or categories. Each respondent was allowed to choose one category. Of the top three groups, most respondents, 50.1%, had 20 years or more of experience. The second largest group, 31.5%, had 10 to 20 years of experience. The third largest group, 14.6%, had 5 to 10 years of experience.

Table 5 below relates years of experience to project success. These responses show positive correlations between project success, as measured by number of successful projects and success/failure ratios, and experience. With 5 to 10 years of experience, for every project that fails, 2.25 succeed. With 20+ years of experience, for every project that fails, 4.625 succeed.

Table 5 Project Success Compared to Overall Work Experience

		Project success or failure				Total
		Successful	% Successful	Failure	% Failure	
How many years have you been in the professional work force?	Less than 1 year	1	100	0	0	1
	1 to 5 years	0	0	2	100	2
	5 to 10 years	9	69.2	4	30.8	13
	10 to 20 years	21	75	7	25	28
	20+ years	37	82.2	8	17.8	45
Total		68	76.4	21	23.6	89

Figure 7 below compares the years of professional experience to project success and failure.

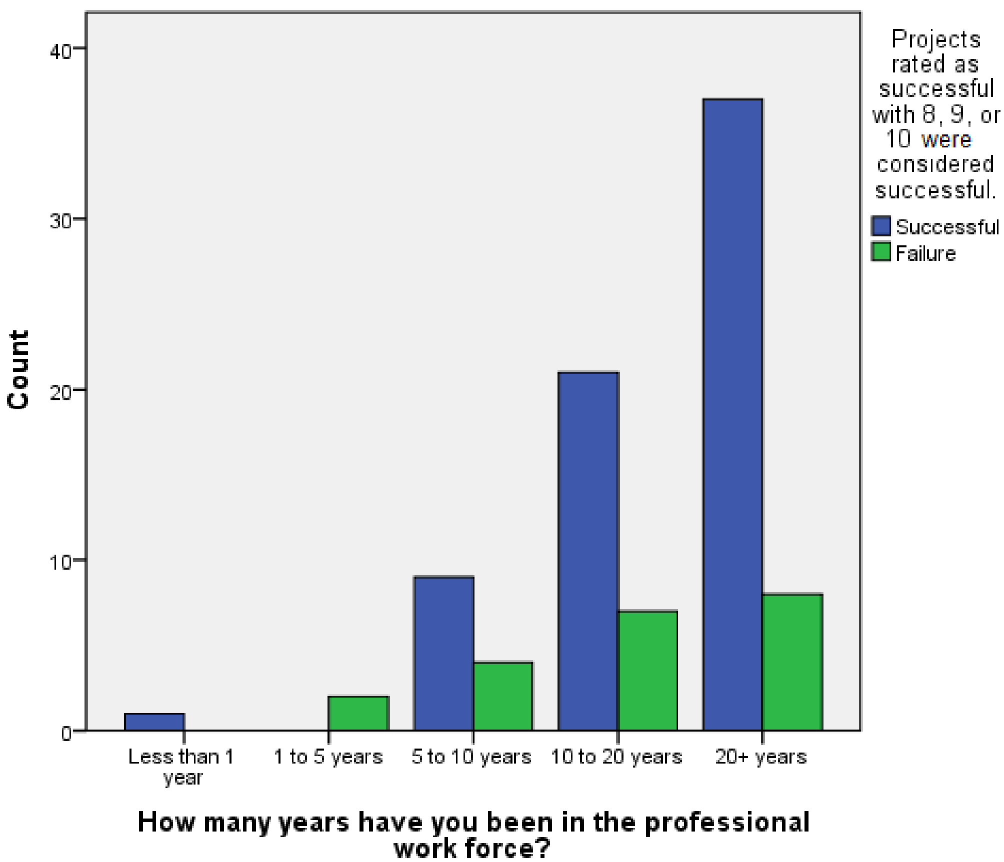

Figure 7 Project Success Rates Compared to Overall Work Experience

Responses were analyzed for statistical significance. The χ^2 value that was obtained, 8.032, was less than the 9.488 needed to reject the null hypothesis at a 95% confidence level (0.05 significance level), but greater than the 7.779 needed for 90% confidence. The p-value, 0.09, suggests correlation between work experience and project success, but is not conclusive.

Table 6 Test of Null Hypothesis Comparing Project Success and Work Experience

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.032[a]	4	.090
Likelihood Ratio	7.595	4	.108
Linear-by-Linear Association	2.807	1	.094
N of Valid Cases	89		

a. 5 cells (50.0%) have expected count less than 5. The minimum expected count is .24.

This data combined responses from project managers and requirements engineers. Below each group is analyzed to determine the impact of work experience on project success for project managers and requirements engineers independently.

Project managers For project managers, 51.0% of respondents had 20 years or more of work experience. 38.8% had 10 to 20 years of experience. 10.2% had 5 to 10 years of experience. There were no responses for less than 5 years of experience. Among project managers, success did increase with experience. Table 7 shows the project managers responses.

Table 7 Project Success Compared to Project Manager Work Experience

		Project success or failure				Total
		Successful	% Successful	Failure	% Failure	
How many years have you been in the professional work force?	5 to 10 years	4	80	1	20	5
	10 to 20 years	15	78.9	4	21.1	19
	20+ years	22	88	3	12	25
Total		41	83.7	8	16.3	49

Figure 8 shows that the most successful projects (ratings 9 and 10) involved the most experienced project managers. Project rated as an 8 involved mostly project managers with 10 to 20 years of experience; the next category of work experience. This suggests that using more experienced project managers increases the likelihood of project success.

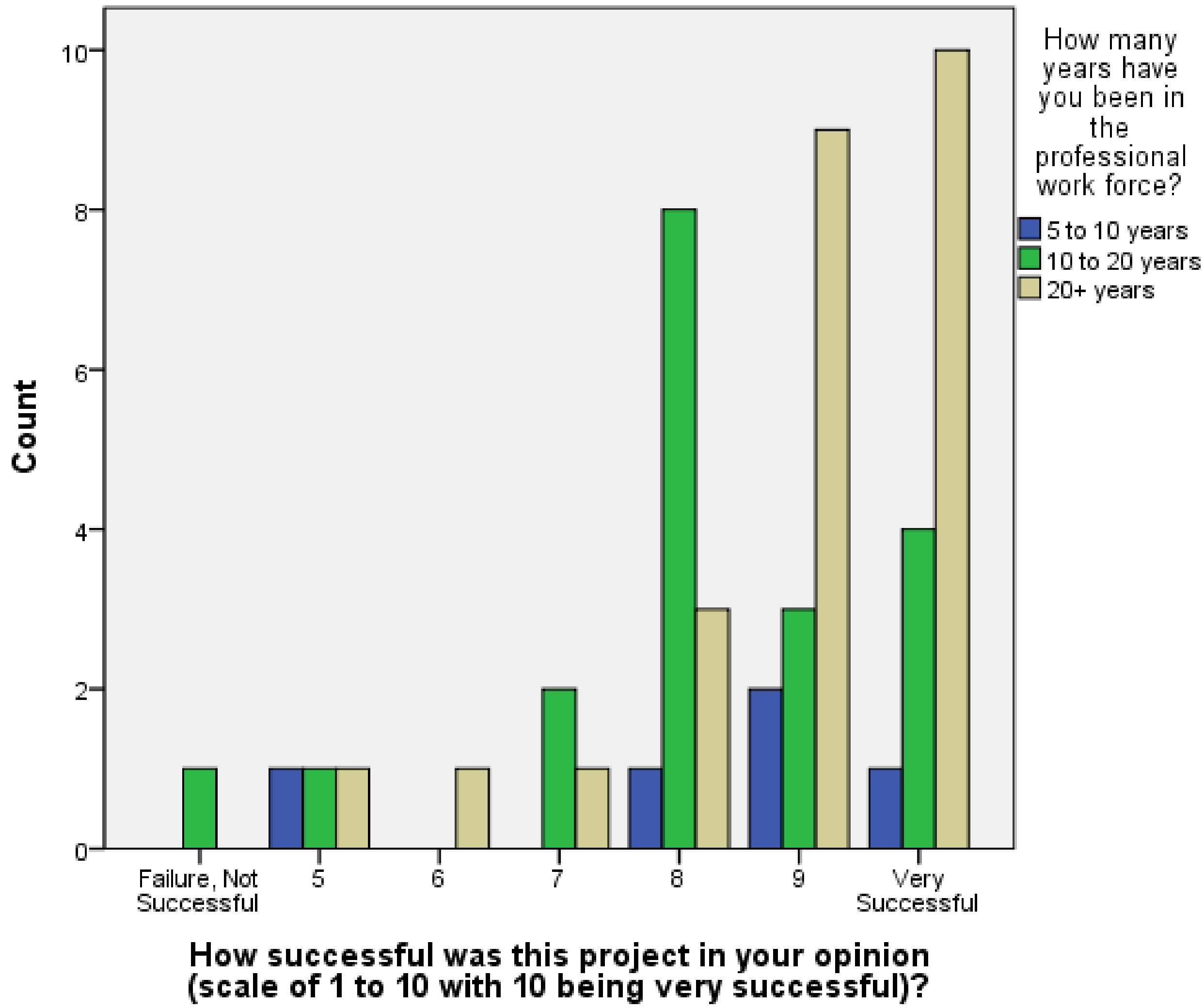

Figure 8 Project Success Compared to Project Manager Work Experience

Requirements engineers Fifty percent of requirements engineers had 20 or more years of experience. The second largest group, 22.5% of the responses, had 10 to 20 years of experience. The third largest group, 20% of responses, had 5 to 10 years of experience. The remaining responses were 5% had 1 to 5 years of experience and 2.5% had less than 1 year of experience. Among requirements engineers, success did increase with experience. Table 8 shows the responses categorized as success or failure.

Table 8 Project Success Compared to Requirements Engineer Work Experience

		Project success or failure				
		Successful	% Successful	Failure	% Failure	Total
How many years have you been in the professional work force?	Less than 1 year	1	100	0	0	1
	1 to 5 years	0	0	2	100	2
	5 to 10 years	5	62.5	3	37.5	8
	10 to 20 years	6	66.7	3	33.3	9
	20+ years	15	75	5	25	20
Total		27	67.5	13	32.5	40

Graphing these responses fails to show a correlation between experience and project success. Most senior requirements engineers worked on projects rated as an 8. An equal number of requirements engineers with 5 to 10, 10 to 20, and more than 20 years of experience worked on projects rated at a 9. No one with lesser experience worked on projects rated as 8, 9, or 10. Only those with 5 or more years of experience worked on projects rated as an 8, 9, or 10. This indicated that for a project to be more successful, the requirements engineer should have at least 5 years of experience.

Summary Project success does increase with more work experience. The null hypothesis for this can be rejected with 90% confidence. Of the projects given to more experienced staff, more will succeed as compared to the amount of success among those with lesser experience. Figure 9 shows the distribution of requirements engineers experience levels among the success ratings.

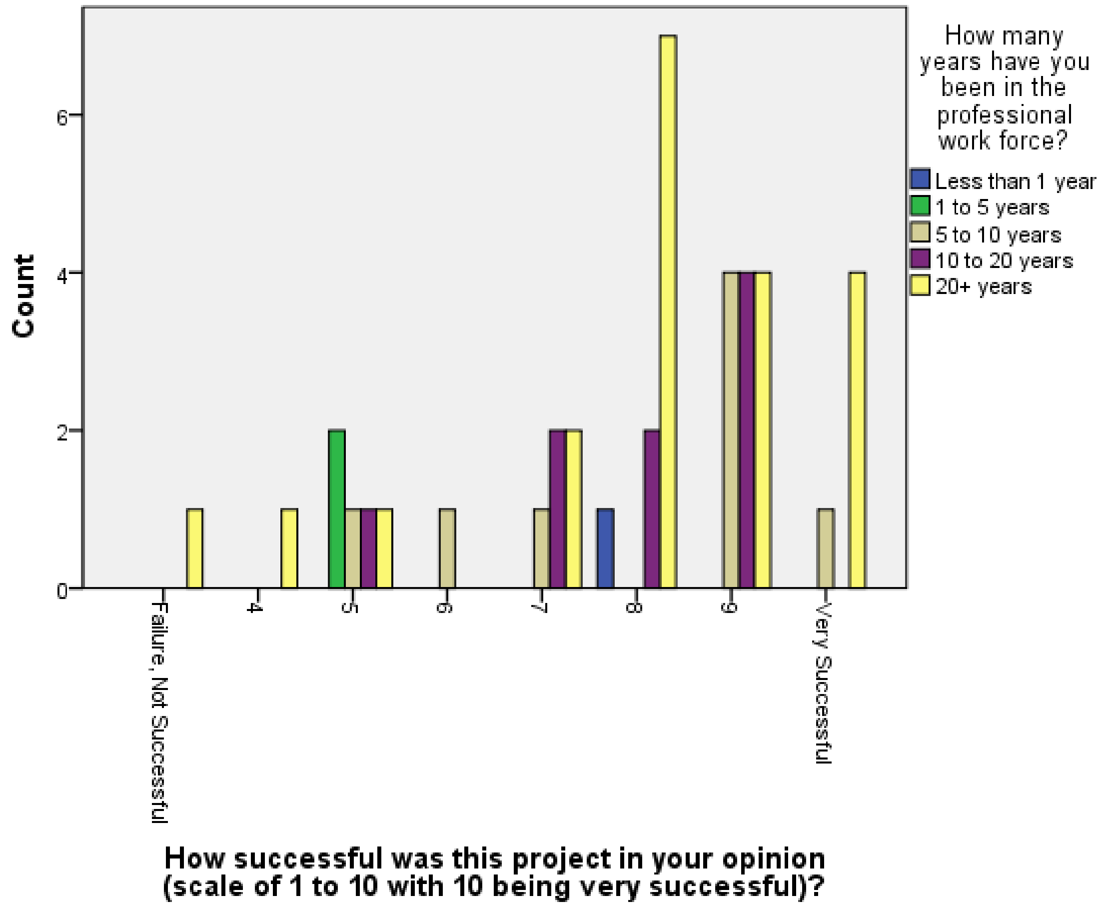

Figure 9 Project Success Compared to Requirements Engineers Work Experience

PM2 / RE2: How many years have you worked in Information Technology?

Respondents were asked how many years they have worked in Information Technology (IT). The years of experience were divided into five ranges or categories. Each respondent was allowed to choose only one category. The largest concentration of response, 39.3%, had 20 years or more of Information Technology experience. The second largest group, 29.2%, had 10 to 20 years of experience. Eighteen percent had 5 to 10 years of experience. Nine percent had 1 to 5 years of experience. Lastly, 4.5% had less than 1 year of experience. Table 9 shows the responses categorized by success or failure.

Table 9 Project Success Compared to Information Technology Work Experience

		Project success or failure				
		Successful	% Success	Failure	% Failure	Total
How many years have you worked in Information Technology?	Less than 1 year	4	100	0	0	4
	1 to 5 years	4	50	4	50	8
	5 to 10 years	13	81.3	3	18.7	16
	10 to 20 years	18	69.2	8	30.8	26
	20+ years	29	82.9	6	17.1	35
Total		68	76.4	21	23.6	89

Figure 10 is a graph of these responses and shows that the number of successful projects increased with Information Technology experience. However, the ratio of successful projects did not increase as much with more IT experience as it did with more professional experience. Those with 1 to 5 years of IT experience had one successful project for each failed project. Those with 5 to 10 years IT experience had 4.33 successes for each failure. Those with 10 to 20 years IT experience dropped to 2.25 successful projects for each failure. Those with more than 20 years of experience had 4.83 successes for each failure. This indicates someone with more IT experience may increase the probability of success, but not to the same extent as having a more senior professional.

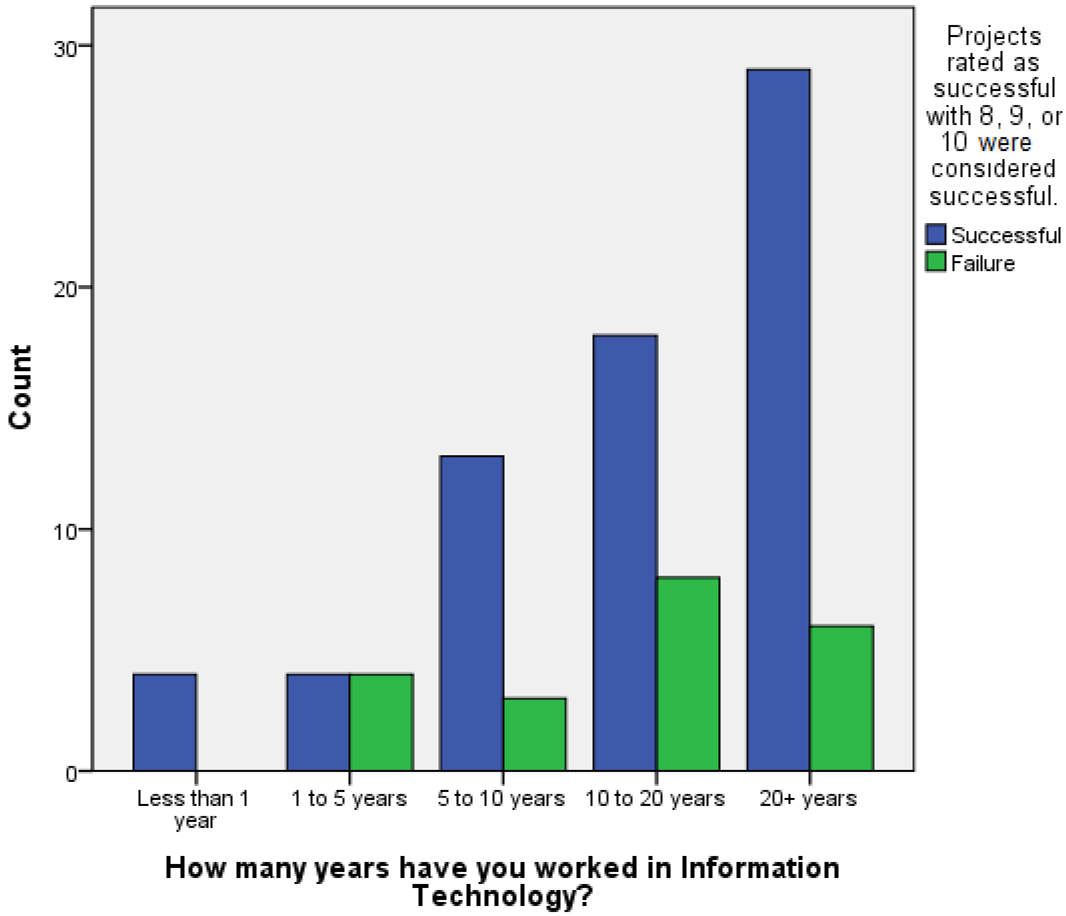

Figure 10 Project Success Compared to Information Technology Work Experience

Table 10 shows the results of the chi-square analysis.

Table 10 Test of Null Hypothesis Comparing Project Success to Information Technology Experience

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.088[a]	4	.193
Likelihood Ratio	6.555	4	.161
Linear-by-Linear Association	.384	1	.535
N of Valid Cases	89		

a. 4 cells (40.0%) have expected count less than 5. The minimum expected count is .94.

Responses were analyzed for statistical significance. A χ^2 value of 9.488 would be necessary to reject the null hypothesis at a 95% confidence level (0.05 significance level). A χ^2 value of 6.088 was caluclated from the data. The p-value is 0.193 which is inconclusive.

Professional work experience can be compared to Information Technology experience. Those with more professional work experience started in Information Technology after entering the work force. Those with less experience started in Information Technology before entering the professional work force. Those with 10 years of experience or more entered the professional work force and then entered Information Technology. Those with less than 10 years of experience started in Information Technology first and then entered the professional work force. Table 11 is a comparison of professional work experiences and Information Technology work experience.

Table 11 Professional Work Experience Compared to Information Technology Experience

	How many years have you been in the professional work force?	*How many years have you worked in Information Technology?*
Less than 1 year	1	4
1 to 5 years	2	8
5 to 10 years	13	16
10 to 20 years	28	26
20+ years	45	35
Total	89	89

Graphing this comparison between professional work experience and Information Technology experience in Figure 11 shows this shift from beginning work in Information Technology before entering the professional work force to entering the professional work force and later working in Information Technology.

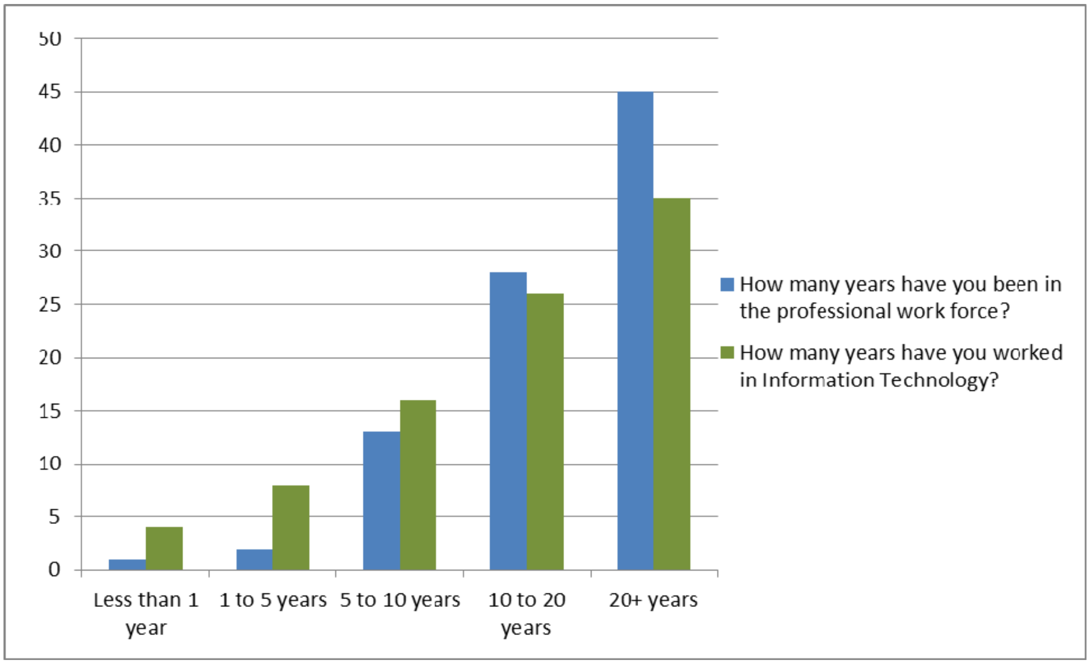

Figure 11 Professional Work Experience Compared to Information Technology Experience

Project managers Below are the responses from the Project Management group of respondents. The largest group, 71.4% of respondents, had more than 10 years of Information Technology experience. Success increases with experience to a point and then levels off. Success among those with 5 to 10 years IT experience and those with 10 to 20 years IT experience is identical. Success among those with 20+ years of experience is only 5% points higher than the previous two groups. This shows that work experience may improve success to a point, but that success will not continue to increase as more IT experience is gained. Table 12 shows the project managers Information Technology experience levels categorized by project success or failure.

Table 12 Project Success Compared to Project Managers Information Technology Work Experience

		Project success or failure				
		Successful	% Success	Failure	% Failure	Total
How many years have you worked in Information Technology?	Less than 1 year	3	100	0	0	3
	1 to 5 years	3	60	2	40	5
	5 to 10 years	5	83.3	1	16.7	6
	10 to 20 years	15	83.3	3	16.7	18
	20+ years	15	88.2	2	11.8	17
Total		41	83.7	8	16.3	49

Figure 12 is a graph of the project manager responses. There is an increase in success for those with 5 years of experience or more. The rate of success does not continue to increase as more experience is gained, but levels off after 5 years.

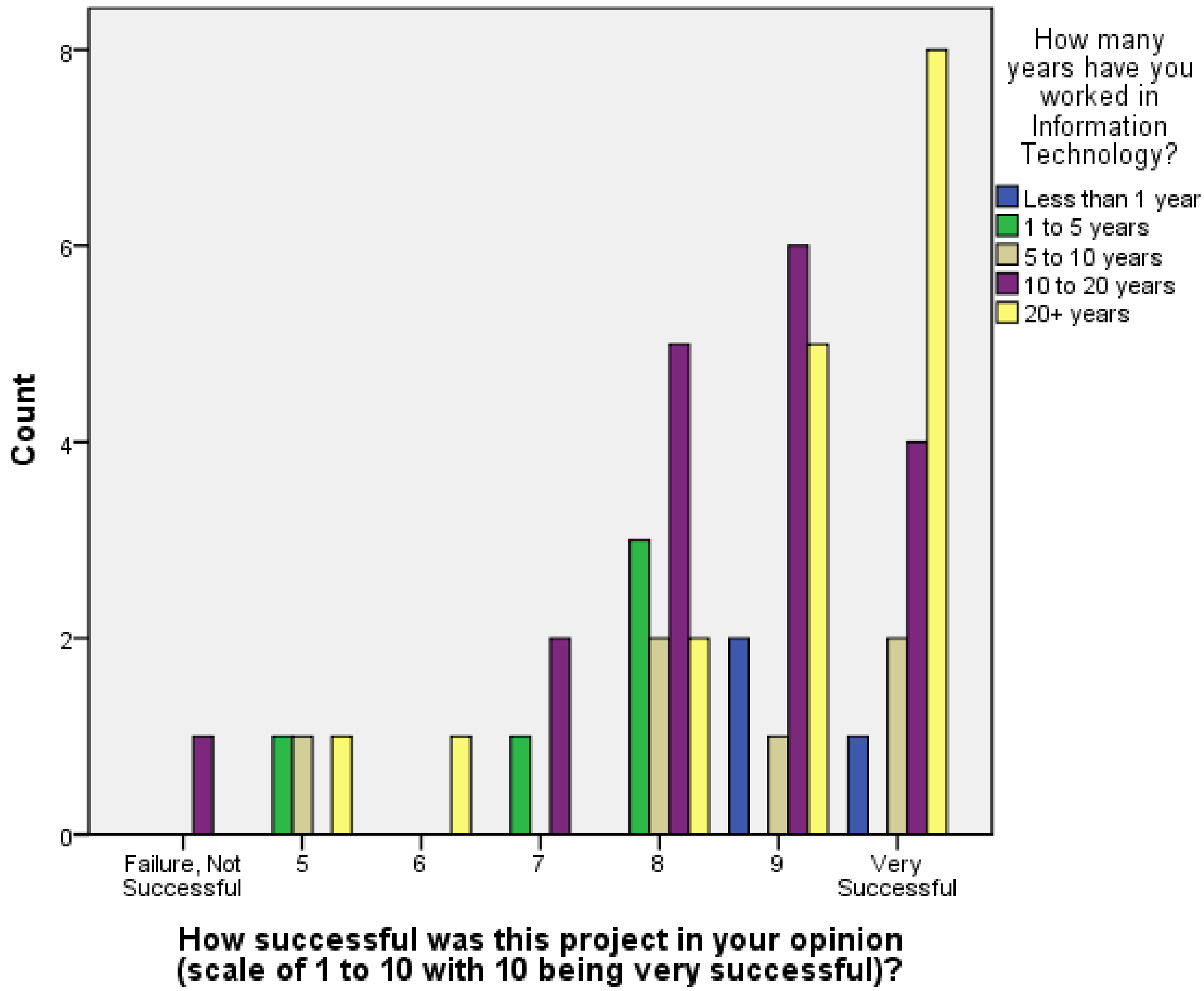

Figure 12 Project Success Compared to Project Managers Information Technology Work Experience

Requirements engineers Among requirements engineers, 45% had 20 or more years of experience. The second largest group, 65%, had more than 10 years of experience. The largest group, 90% of respondents, had more than 5 years of experience. Table 13 provides requirements engineers experience levels with projects categorized by success or failure.

Table 13 Project Success Compared to Requirements Engineers Information Technology Work Experience

		Project success or failure				Total
		Successful	% Success	Failure	% Failure	
How many years have you worked in Information Technology?	Less than 1 year	1	100	0	0	1
	1 to 5 years	1	33.3	2	66.7	3
	5 to 10 years	8	80	2	20	10
	10 to 20 years	3	37.5	5	62.5	8
	20+ years	14	77.8	4	22.2	18
Total		27	67.5	13	32.5	40

Figure 13 is a graph of the requirements engineers responses. Years of IT experience do not correlate with project success. For those with 1 to 5 years and 10 to 20 years, for every failed project, 0.5 and 0.6 projects succeed respectively. For those with 5 to 10 and more than 20 years experience, for every failed project, 4 and 3.5 projects succeed respectively. There is a downward turn in success for years 1to 5 and 10 to 20. This suggests that the optimal person would have either 5 to 10 years experience or more than 20 years of experience.

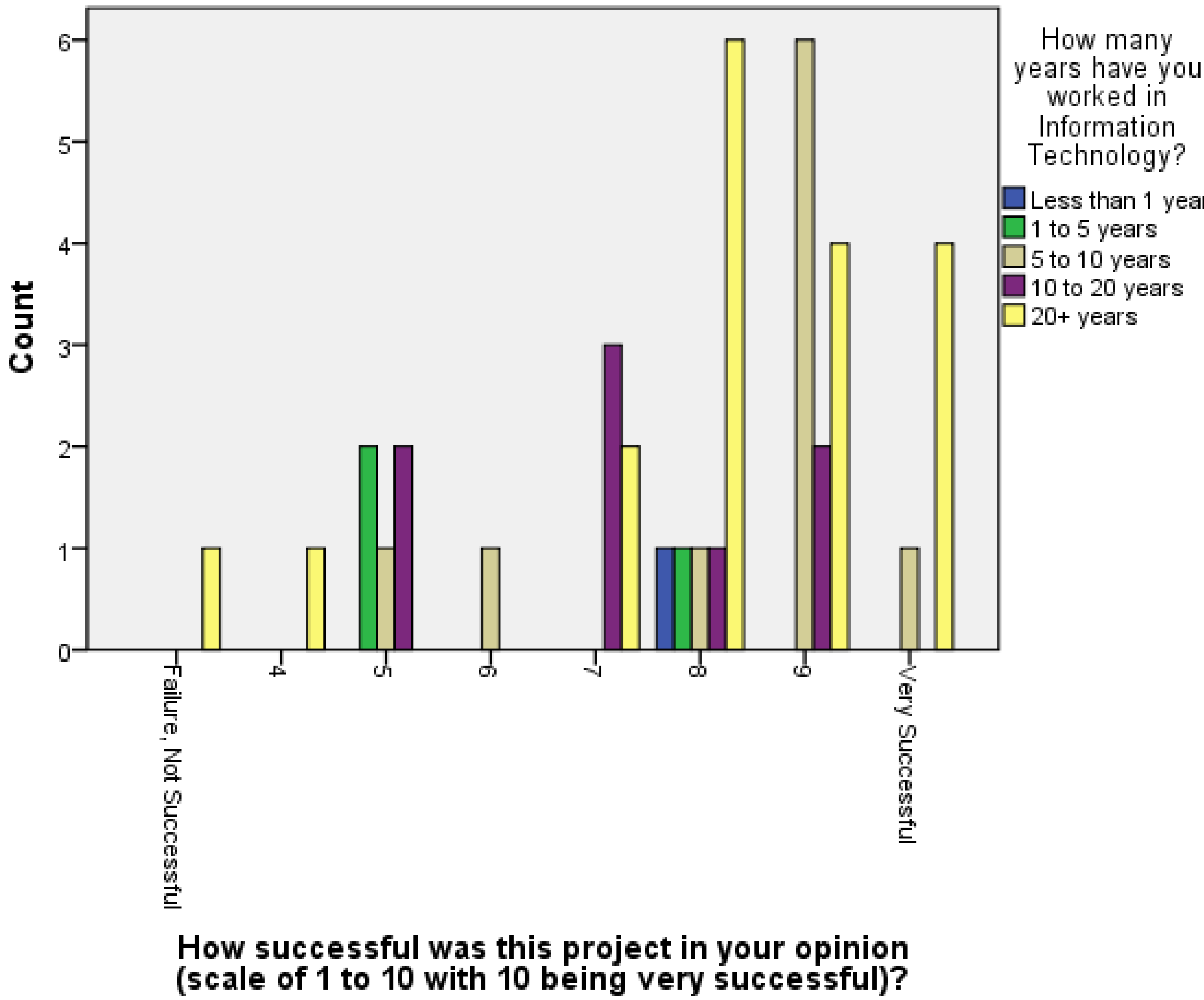

Figure 13 Project Success Compared to Requirements Engineers Information Technology Work Experience

<u>Summary</u> Assigning a Project Manger with at least 5 years experience in Information Technology may increase success. It may also be helpful to have a requirements engineer with either 5 to 10 years of experience in IT or more than 20 years of experience in IT. However, the null hypothesis cannot be rejected, so IT experience does not directly impact project success.

PM3: How many years have you been in a project management role?

Project managers were asked how many years they have served as a project manager. Project managers who worked on the most successful projects had at least 5 years of experience as a project manager.

Table 14 Project Success Compared to Project Management Experience

		Project success or failure				
		Successful	% Success	Failure	% Failure	Total
How many years have you been in a project management role?	1 to 5 years	5	55.6	4	44.4	9
	5 to 10 years	14	93.3	1	6.7	15
	10 to 20 years	16	88.9	2	11.1	18
	20+ years	6	85.7	1	14.3	7
Total		41	83.7	8	16.3	49

Figure 14 is a graph of these responses and shows that more successful projects have project managers with at least 5 years of experience as project managers. For project managers with 5 to 10 years of experience in project management role, for every failed project, 14 projects succeeded. Those with 10 to 20 years of experience worked with 8 successful projects for each failed project. Those with 20 years or more of experience worked with 6 successful projects for each failed project.

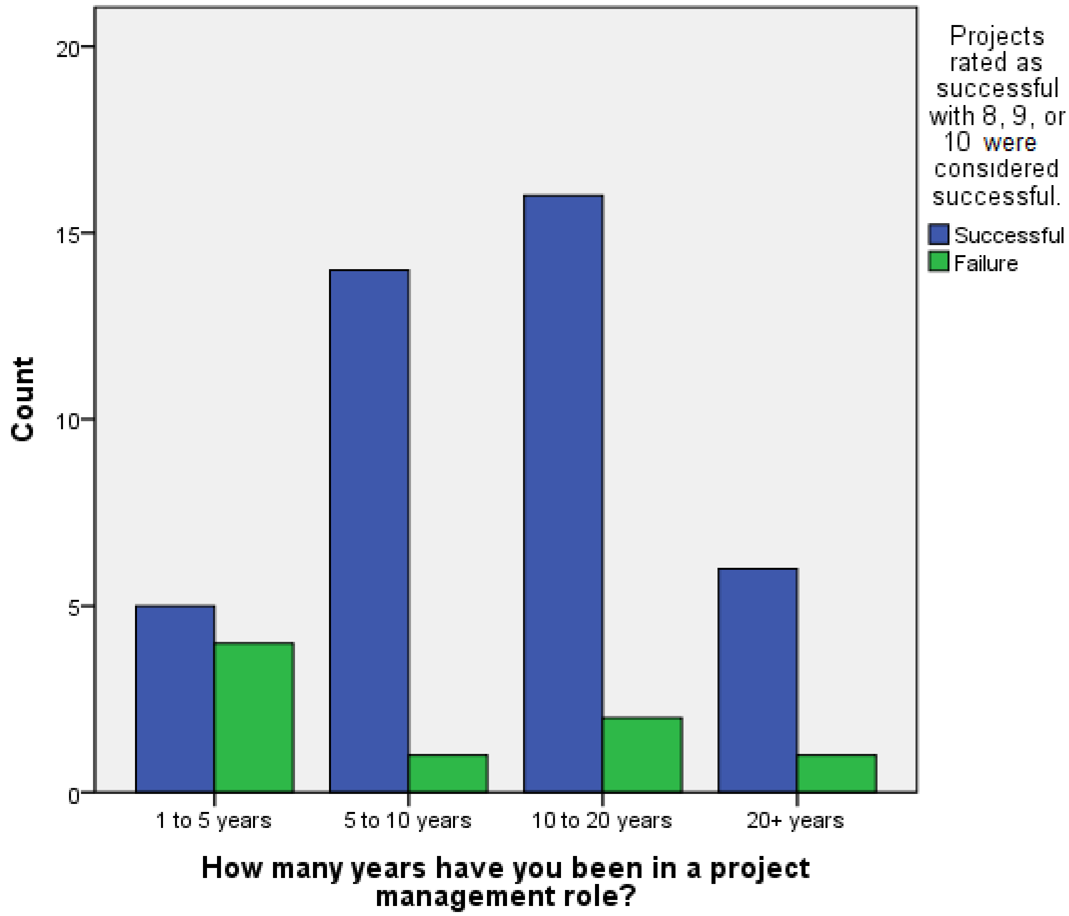

Figure 14 Project Success Compared to Project Management Experience

Table 15 contains the results of the chi-square analysis.

Table 15 Test of the Null Hypothesis Comparing Project Success and Project Management Experience

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.613[a]	3	.085
Likelihood Ratio	5.602	3	.133
Linear-by-Linear Association	2.287	1	.130
N of Valid Cases	49		

a. 4 cells (50.0%) have expected count less than 5. The minimum expected count is 1.14.

The null hypothesis can be rejected with 90% confidence, but not with 95% confidence. For 95% (.05 significance), a χ^2 value of 7.815 would be needed. For 90% confidence, the value is 6.251. The χ^2 value for this data is 6.613, which is between 6.251 and 7.815. The p-value is 0.085, suggesting a possible correlation between years of project management experience and project success.

Summary There is a strong correlation between years of experience in the project management role and project success. Those with 10 to 20 years of experience reported the greatest number of successful projects. Those with 5 to 10 years of experience had the greatest successful project to failed project ratio. The null hypothesis can be rejected with 90% confidence. Selecting someone with more project management experience can increase the likelihood of project success.

RE3: How many years have you been in a requirements analyst role?

Requirements engineers were asked how many years they have served in the requirements engineer role. Requirements engineers with 5 to 10 years of requirements engineering experience worked most on projects rated as a 9 on the project success scale. This was the largest concentration of the experience levels. This indicates that it may benefit a project when the requirements engineer has been in this role for at least 5 years. The responses with projects categorized as success or failure is contained in Table 16.

Table 16 Project Success Compared to Requirements Engineering Experience

		Project success or failure				
		Successful	% Success	Failure	% Failure	Total
How many years have you been in a requirements analyst role?	Less than 1 year	2	50	2	50	4
	1 to 5 years	4	44.4	5	55.6	9
	5 to 10 years	10	71.4	4	28.6	14
	10 to 20 years	5	71.4	2	28.6	7
	20+ years	6	100	0	0	6
Total		27	67.5	13	32.5	40

Graphing these responses shows a high concentration of those with 5 to 10 years of requirements engineering experience on successful projects. For those with 1 to 5 years of experience, for every failed project, requirements engineers worked on 0.8 successful projects. For those with 5 to 10 years and 10 to 20 years of experience, for every failed project, requirements engineers worked on 2.5 successful projects. All projects submitted by those with 20 years or more of experience succeeded. This shows that success increases with more experience in the requirements analyst role. Figure 15 is a graphs of responses with projects categorized as success or failure.

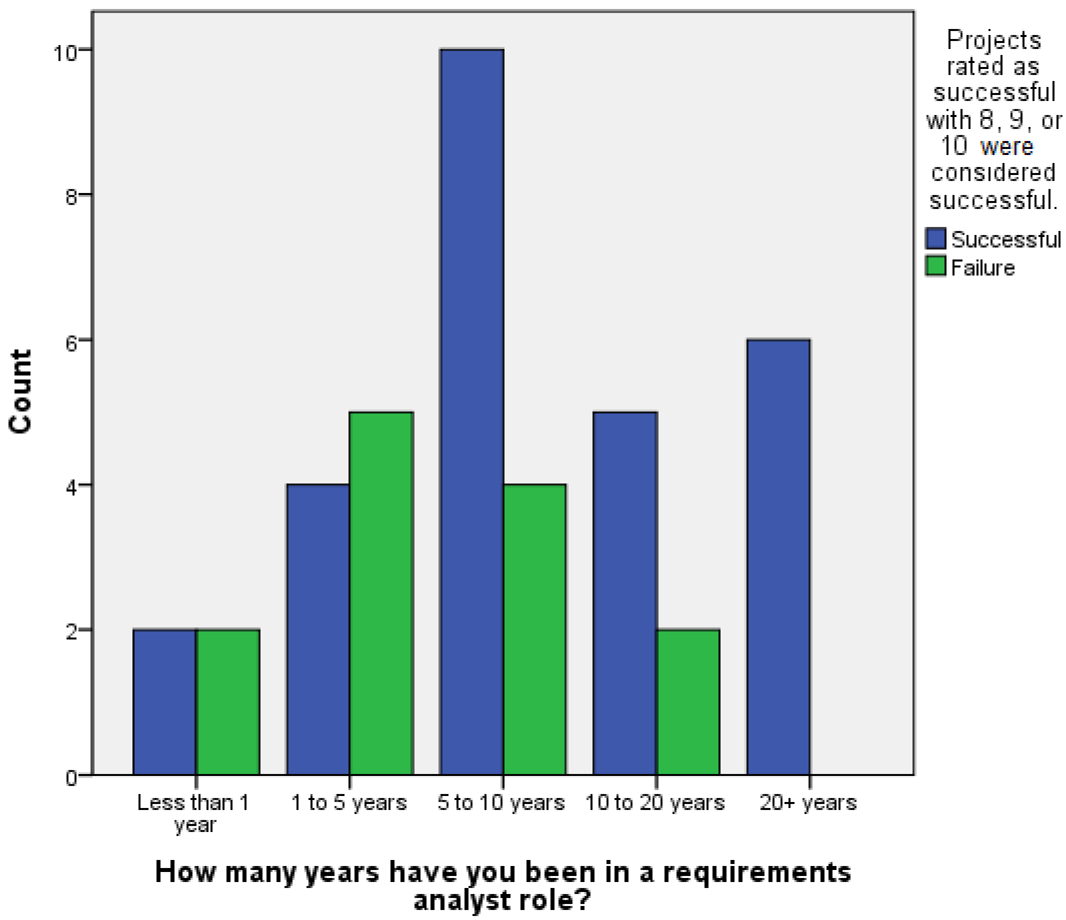

Figure 15 Project Success Compared to Requirements Engineering Experience

Table 17 provides the results of the chi-square analysis.

Table 17 Test of the Null Hypothesis Comparing Project Success to Requirements Analysis Experience

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.776[a]	4	.217
Likelihood Ratio	7.409	4	.116
Linear-by-Linear Association	4.653	1	.031
N of Valid Cases	40		

a. 8 cells (80.0%) have expected count less than 5. The minimum expected count is 1.30.

These responses were analyzed for their statistical significance. To reject the null hypothesis with 95% confidence (0.05 significance), a χ^2 value of 9.488 would be needed. The value 5.776 is well below 9.488 and therefore the null hypothesis cannot be rejected. The p-value is 0.217 which means it is inconclusive that requirements analysis experience impacts project success.

Summary While project success appears to increase with more experience in the requirements engineering role, there is not enough data to statistically support this conclusion. Those with 5 years or more experience as a requirements engineer were more successful in the data of this survey.

PM6 / RE6: What positions have you held during your career (select all that apply)?

Respondents were asked what positions they had held during their careers. Individuals could choose multiple positions and were asked to select any position they had held. The most common positions held among the respondents were project manager, business analyst / requirements analyst / requirements engineer, and software engineer / programmer (highlighted in Table 18 below).

Table 18 Distribution of Positions Held by All Respondents

	Responses		Percent of Cases
	N	Percent	
Chief Executive Officer, Chief Information Technology Officer, or other top management position	8	1.8%	7.6%
Director of Project Management/Program Management Office	12	2.7%	11.4%
Educator/Trainer	33	7.5%	31.4%
Functional Manager/Resource Manager	36	8.2%	34.3%
Project Management Consultant	30	6.8%	28.6%
Project Manager	74	16.9%	70.5%
Program Manager	35	8.0%	33.3%
Project Management Specialist	23	5.2%	21.9%
Business Analyst / Requirements Analyst / Requirements Engineer	57	13.0%	54.3%
Software Architect	29	6.6%	27.6%
Software Engineer / Programmer	52	11.8%	49.5%
Database Administrator	12	2.7%	11.4%
Quality Assurance Analyst	15	3.4%	14.3%
Systems Administrator	14	3.2%	13.3%
Network Administrator	9	2.1%	8.6%
Total	439	100.0%	418.1%

The greatest number of projects were reported by those who had held project manager, business analyst/requirements analyst/requirements engineer, and software engineer/programmer positions. The positions that reported the highest percentage of successful projects were CEO/CIO/top management, directors of project management offices (PMOs), program managers, program management specialists, and quality assurance analysts. Table 19 shows the roles compared to project success or failure.

Table 19 Positions Served Compared to Project Success

		Project success or failure.				Total
		Successful	% Successful	Failure	% Failure	
What positions have you held during your career (select all that apply)?	Chief Executive Officer, Chief Information Technology Officer, or other top management position	7	100	0	0	7
	Director of Project Management/Program Management Office	11	100	0	0	11
	Educator/Trainer	27	87.1	4	12.9	31
	Functional Manager/Resource Manager	29	93.5	2	6.5	31
	Project Management Consultant	28	93.3	2	6.7	30
	Project Manager	52	78.8	14	21.2	66
	Program Manager	30	96.7	1	3.3	31
	Project Management Specialist	20	95.2	1	4.8	21
	Business Analyst / Requirements Analyst / Requirements Engineer	39	79.6	10	20.4	49
	Software Architect	22	81.5	5	18.5	27
	Software Engineer / Programmer	36	73.5	13	26.5	49
	Database Administrator	9	90	1	10	10
	Quality Assurance Analyst	12	100	0	0	12
	Systems Administrator	9	75	3	25	12
	Network Administrator	6	85.7	1	14.3	7

These data were grouped to identify correlations between positions and project success with the χ^2 test. The 5 categories grouped management positions, project management related positions, and various IT positions. Educators or trainers and Business Analysts remained and were not grouped with other data. Table 20 shows these 5 categories compared to project success or failure.

Table 20 Management, Educator, Project Management, Business Analysis, IT Positions Grouped and Compared to Project Success

		Project success or failure.				Total
		Successful	% Successful	Failure	% Failure	
What positions have you held during your career (select all that apply)?	Chief Executive Officer, Chief Information Technology Officer, or other top management position; Director of Project Management/Program Management Office; Functional Manager/Resource Manager	47	95.9	2	4.1	49
	Educator/Trainer	27	87.1	4	12.9	31
	Project Management Consultant; Project Manager; Program Manager; Project	130	87.8	18	12.2	148
	Business Analyst / Requirements Analyst / Requirements Engineer	39	79.6	10	20.4	49
	Software Architect; Software Engineer / Programmer; Database Administrator; Quality Assurance Analyst ; Systems Administrator; Network Administrator	94	78.1	23	21.9	117

With this grouping, the p-value from a χ^2 test is 0.0634. This is not conclusive, but suggests that those who have served in certain positions are correlated with project success. The most successful are those who have served in a management position. This is followed by those who have served in a project management position. Choosing someone who has served in a management position or a project management related position may increase the likelihood for project success.

Project managers Among project managers, the most frequently reported positions on successful projects were project manager, software engineer/programmer, and program manager respectively. The positions within project managers that reported the most success were CEO/CIO/top management, director of PMOs, functional managers, program managers, database administrators, and quality assurance analysts. The least success was reported by those who had been software engineers/programmers. Table 21 provides the project managers responses compared to project success.

Table 21 Positions Served by Project Managers Compared to Project Success

		Project success or failure.				Total
		Successful	% Successful	Failure	% Failure	
What positions have you held during your career (select all that apply)?	Chief Executive Officer, Chief Information Technology Officer, or other top management position	6	100	0	0	6
	Director of Project Management/Program Management Office	10	100	0	0	10
	Educator/Trainer	18	90	2	10	20
	Functional Manager/Resource Manager	23	95.8	1	4.2	24
	Project Management Consultant	21	95.5	1	4.5	22
	Project Manager	38	86.4	6	13.6	44
	Program Manager	27	96.4	1	3.6	28
	Project Management Specialist	15	93.8	1	6.2868	16
	Business Analyst / Requirements Analyst / Requirements Engineer	13	86.7	2	13.3	15
	Software Architect	12	92.3	1	7.7	13
	Software Engineer / Programmer	24	77.4	7	22.6	31
	Database Administrator	5	100	0	0	5
	Quality Assurance Analyst	5	100	0	0	5
	Systems Administrator	6	85.7	1	14.3	7
	Network Administrator	5	83.3	1	16.7	6

Requirements engineers For requirements engineers, the positions reported most frequently on the most successful projects were business analyst/requirements analyst/requirements engineer, project manager, and software engineer/programmer respectively. Those with the most success were CEO/CIO/top managers, directors of PMOs, program managers, project management specialists, quality assurance analysts, and network administrators. The least success was reported by those who had been project managers and software engineers/programmers were the second least. Table 22 provides the requirements engineers responses compared to project success and failure.

Table 22 Positions Served by Requirements Engineers Compared to Project Success

		Project success or failure.				Total
		Successful	% Successful	Failure	% Failure	
What positions have you held during your career (select all that apply)?	Chief Executive Officer, Chief Information Technology Officer, or other top management position	1	100	0	0	1
	Director of Project Management/Program Management Office	1	100	0	0	1
	Educator/Trainer	9	81.1	2	18.2	11
	Functional Manager/Resource Manager	6	85.7	1	14.3	7
	Project Management Consultant	7	87.5	1	12.5	8
	Project Manager	14	63.6	8	36.4	22
	Program Manager	3	100	0	0	3
	Project Management Specialist	5	100	0	0	5
	Business Analyst / Requirements Analyst / Requirements Engineer	26	74.5	8	23.5	34
	Software Architect	10	71.4	4	28.6	14
	Software Engineer / Programmer	12	66.7	6	33.3	18
	Database Administrator	4	80	1	20	5
	Quality Assurance Analyst	7	100	0	0	7
	Systems Administrator	3	60	2	40	5
	Network Administrator	1	100	0	0	1

Summary Those who manage successful projects may be promoted within their careers. Those who had served as CEO/CIO/top manager were most successful. Quality assurance analysts also had a high percentage of success which may indicate that such training would be helpful to those managing projects. The lower percentage of successful projects for project managers and software engineers indicates there may be difficulties moving between these roles which could lead to less successful projects.

PM7 / RE7: What is the highest academic degree you have received?

Most respondents had a bachelor's degree. Almost the same number had a master's degree. All education levels reported some successful projects. More education did not result in more successful projects. Table 23 illustrates the education levels reported compared to project success.

Table 23 Project Success Compared to Education Levels

		Project success or failure				
		Successful	% Success	Failure	% Failure	Total
What is the highest academic degree you have received?	High School/Secondary Diploma	1	100	0	0	1
	Some College or Associate's Degree	3	100	0	0	3
	Bachelor's Degree	35	85.4	6	14.6	41
	Master's Degree	24	63.2	14	36.8	38
	Doctorate	5	83.3	1	16.7	6
Total		68	76.4	21	23.6	89

Figure 16 below shows that those with a bachelor's degree reported the greatest number of successful projects. Those with a bachelor's degree also had the highest percentage of success followed closely by those with doctorates.

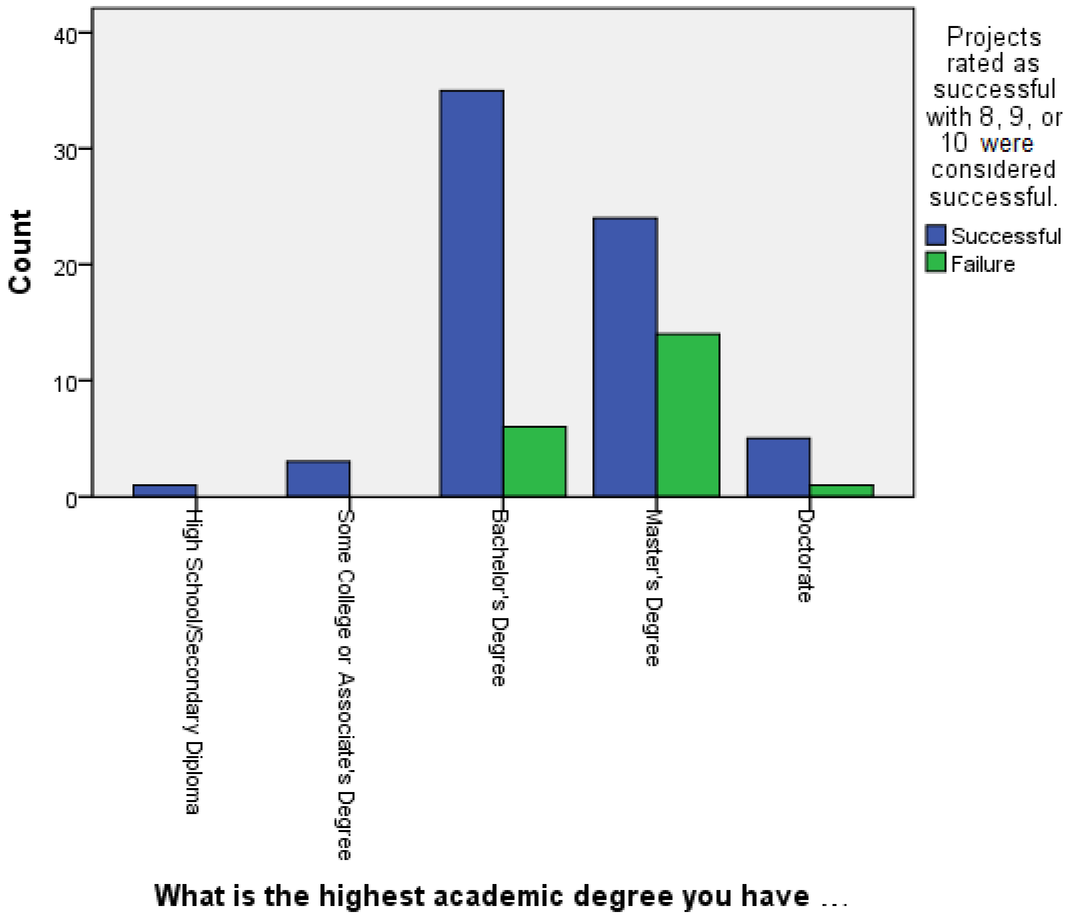

Figure 16 Project Success Compared to Education Levels

Analyzing this data for statistical significance does not reject the null hypothesis. To reject the null hypothesis with 95% confidence, a χ^2 value of 9.488 would be needed. For this data, the χ^2 value is 6.920. The chi-square analysis is shown in Table 24.

Table 24 Test of Null Hypothesis Comparing Project Success to Education Levels

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.920[a]	4	.140
Likelihood Ratio	7.694	4	.103
Linear-by-Linear Association	3.435	1	.064
N of Valid Cases	89		

a. 6 cells (60.0%) have expected count less than 5. The minimum expected count is .24.

Data were then grouped into two categories: those with a high-school diploma, some college or associates degree, or bachelor's degree and those with a master's or doctorate degree. The chi-square test was performed on this grouping. Table 25 provides the results of the chi-square analysis.

Table 25 Data Grouped by Those With up to Bachelor's Degree and Those with Master's or Doctorate vs. Project Success

		Project success or failure				Total
		Successful	% Success	Failure	% Failure	
What is the highest academic degree you have received?	High School/Secondary Diploma; Some College or Associate's Degree; Bachelor's Degree	39	86.7	6	13.3	45
	Master's Degree or Doctorate	29	65.9	15	34.1	44
Total		68	76.4	21	23.6	89

The p-value for this grouping, 0.0397, shows conclusively that level of education impacts project success. Those with up to a bachelor's degree had 6.5 project successes for each project failure. Those with a master's or a doctorate degree had 1.9 successes for each failure. This means that it will increase project success to have those with up to a bachelor's degree, but not those with higher degrees.

<u>Project manager</u> Most project managers had a bachelor's or a master's degree. Those with a doctorate had the highest percentage of successful projects followed by those with a bachelor's degree. Those with a High School Diploma or Some College/Associate's degree also had high success, but there were limited responses in these groups. Table 26 provides the project managers responses compared to project success. Figure 17 is a graph of these responses with project success ratings.

Table 26 Project Success Compared to Education Levels among Project Managers

		Project success or failure				Total
		Successful	% Success	Failure	% Failure	
What is the highest academic degree you have received?	High School/Secondary Diploma	1	100	0	0	1
	Some College or Associate's Degree	1	100	0	0	1
	Bachelor's Degree	17	85	3	15	20
	Master's Degree	18	78.3	5	21.7	23
	Doctorate	4	100	0	0	4
Total		41	83.7	8	16.3	49

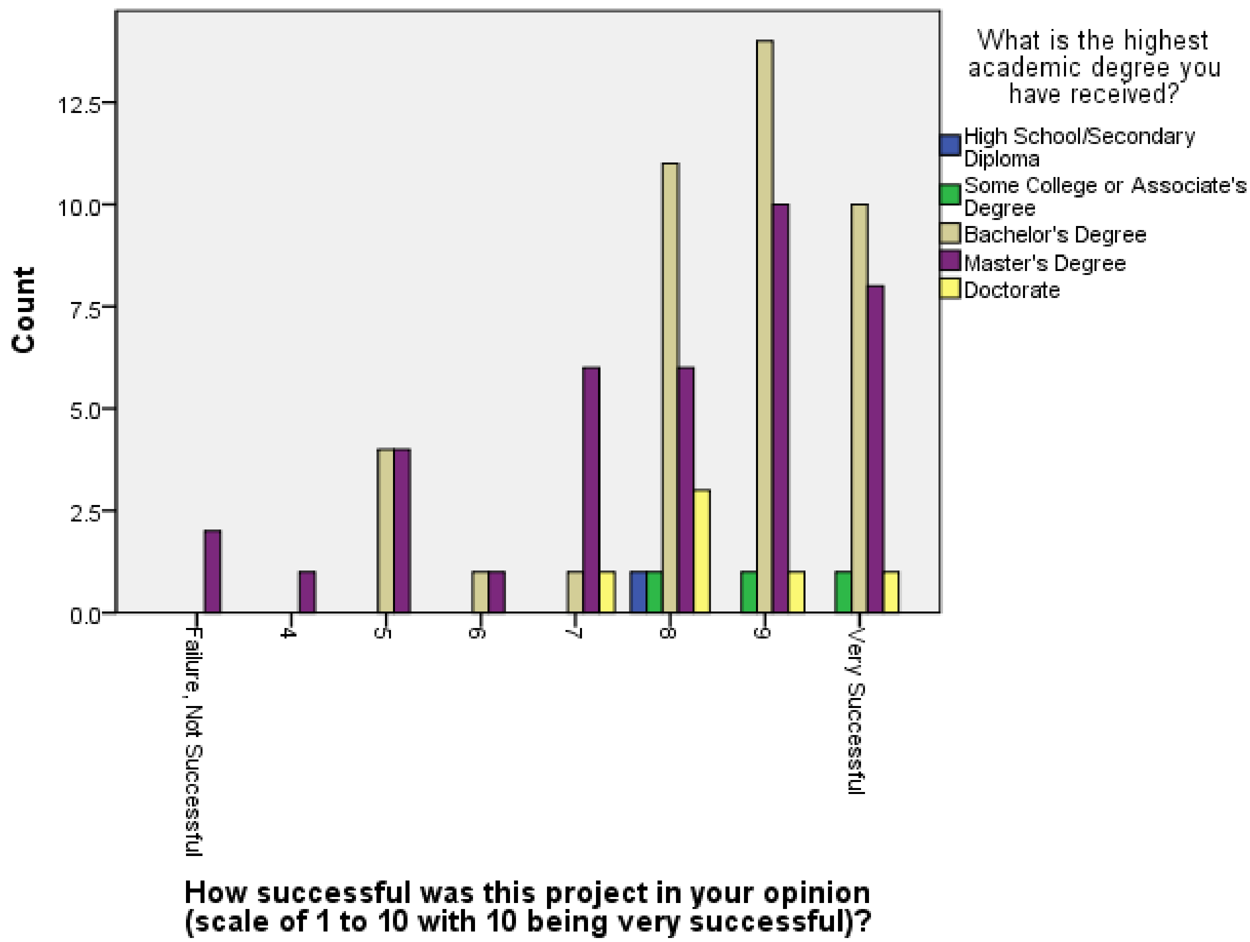

Figure 17 Project Success Compared to Education Levels Among Project Managers

Requirements engineers Most requirements engineers had a bachelor's with the second largest group having a master's. Those with some college or associate's degrees had the highest percentage of successful projects. Those with master's degrees had the lowest percentage of success. Table 27 provides the requirements engineers responses compared to project success and failure.

Table 27 Project Success Compared to Education Levels among Requirements Engineers

		Project success or failure				
		Successful	% Success	Failure	% Failure	Total
What is the highest academic degree you have received?	High School/Secondary Diploma	0	0	0	0	0
	Some College or Associate's Degree	2	100	0	0	2
	Bachelor's Degree	18	85.7	3	14.3	21
	Master's Degree	6	40	9	60	15
	Doctorate	1	50	1	50	2
Total		27	67.5	13	32.5	40

Graphing these responses shows that those with bachelor's degrees work mostly on projects with a success rating of 8, 9, or 10. Of the responses, 85.1% of those with bachelor's degrees worked on these projects. This shows that there may be a benefit for a requirements engineer to have a bachelor's degree. However, those with master's or doctorate degrees did not work on mostly successful projects. A requirements engineer obtaining a degree above a bachelor's may offer diminishing returns. Figure 18 is a graph of the requirements engineers education levels and the project success rating reported.

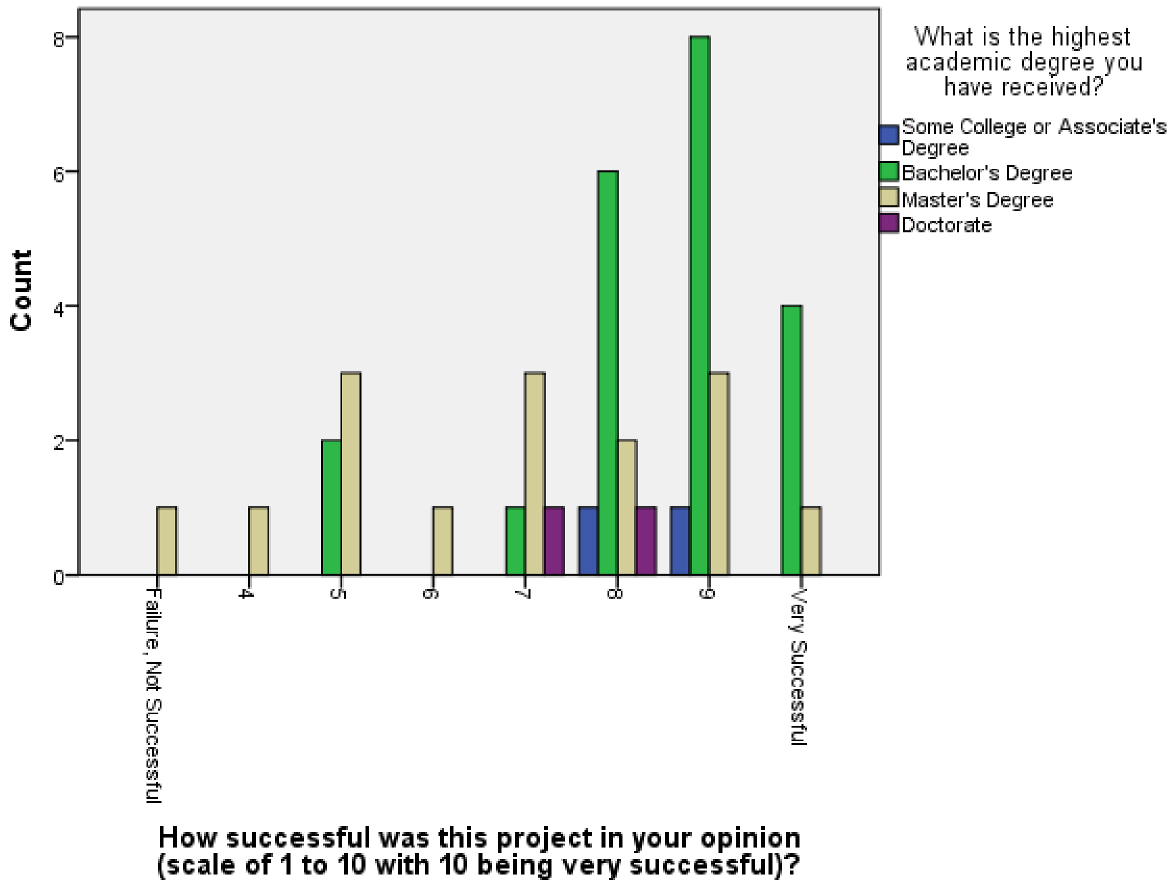

Figure 18 Project Success Compared to Education Levels Among Requirements Engineers

Summary It increases the probability of project success to have someone with up to a bachelor's degree. It is detrimental to projects to have someone with a master's or a doctorate degree. The null hypothesis could be rejected for these conditions making it conclusive that the level of education does impact project success.

PM8 / RE8: What best describes your education background (if you've studied more than one area, choose the field where you have spent the most time or effort)?

The greatest numbers of successful projects were reported by those with an education based on Computer and Information Science. This was followed by Business. Social Sciences and Engineering had the third highest number of projects. Table 28 shows the educational background and project success.

Table 28 Project Success Compared to Primary Educational Background

		Project success or failure				Total
		Successful	% Success	Failure	% Failure	
What best describes your educational background (if you've studies more than one area, choose the field where you have spent the most time or effort)?	Arts	3	100	0	0	3
	Business	14	73.7	5	26.3	19
	Computer/Information Sciences	32	76.2	10	23.8	42
	Engineering	8	66.7	4	33.3	12
	Mathematics	2	100	0	0	2
	Natural Sciences (such as Biology, Chemistry, Physics)	1	100	0	0	1
	Social Sciences (such as Sociology, Psychology, Political Science)	8	88.9	1	11.1	9
	Other	0	0	1	100	1
Total		68	76.4	21	23.6	89

Figure 19 is a graph of these responses showing that those with Computer/Information science degrees work mostly on successful projects. Of the responses, 76.2% studied Computer/Information Science and worked on these more successful projects. The next largest group of responses was from those with a Business background and 73.7% of these respondents worked on successful projects. 66.7% of engineers worked on successful projects. Those with Mathematics, Natural Science, and Art backgrounds also worked on more successful projects, but there were a limited number of responses.

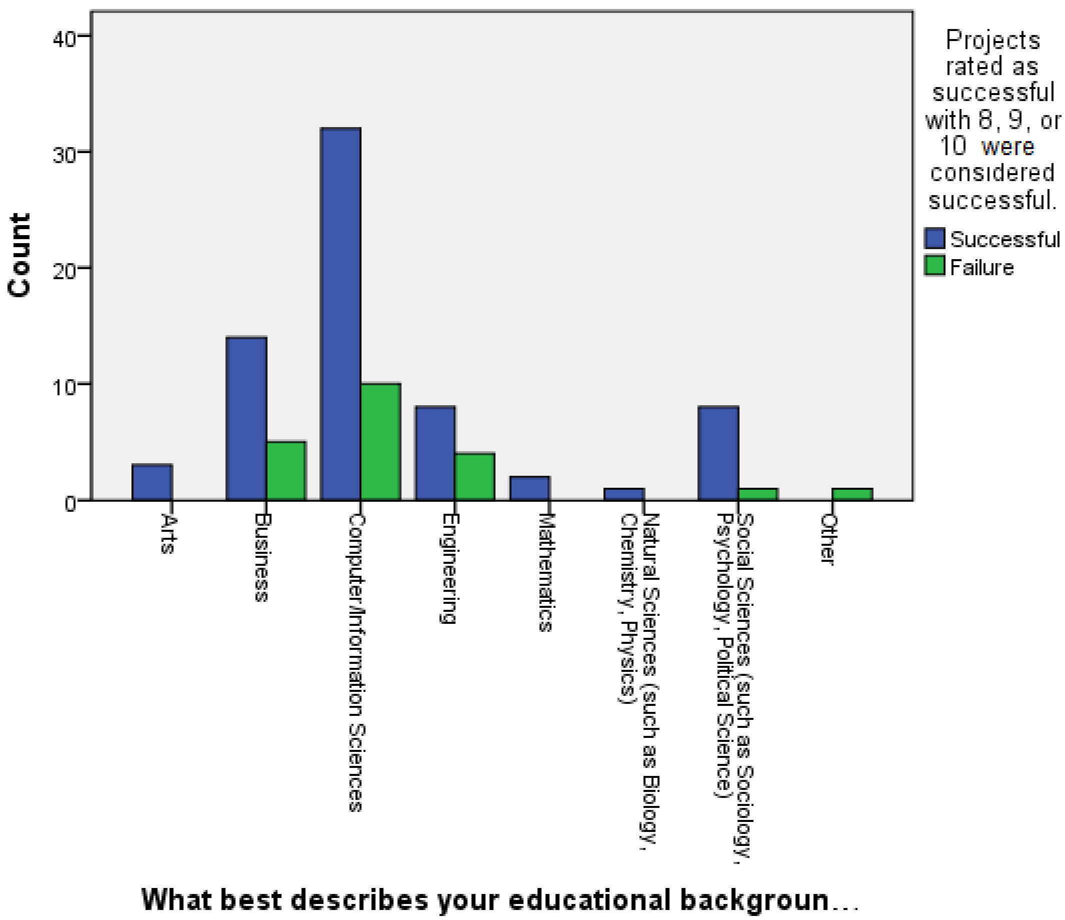

Figure 19 Project Success Compared to Primary Educational Background

These data were tested for statistical significance. To reject the null hypothesis with 95% confidence, value of 14.067 would be needed. Since the value for this data is 6.579, the null hypothesis cannot be rejected. This means that the educational background cannot be shown to impact project success. The data was also grouped in several ways to identify correlations among a collection of educational areas, but no conclusive or suggestive correlations were found. Table 29 contains the results of the chi-square analysis.

Table 29 Test of Null Hypothesis Comparing Project Success to Primary Educational Background

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.579[a]	7	.474
Likelihood Ratio	7.693	7	.360
Linear-by-Linear Association	.013	1	.909
N of Valid Cases	89		

a. 11 cells (68.8%) have expected count less than 5. The minimum expected count is .24.

Project managers   Most project managers had a Computer/Information Science background. 78.9% of those with the Computer/Information science background worked on successful projects. The second largest group was Engineers and 70% of engineers worked on successful projects. The third largest group was those with a Business degree and 100% of these respondents worked on successful projects. This indicates that it maybe beneficial for the Project Manger to have a business degree. Mathematics and Natural Sciences also worked on 100% successful projects. However, there were very few responses from these groups. Business and Social Sciences had the highest ratio of successful projects of the projects they managed. Table 30 contains the project managers responses.

Table 30 Project Success Compared to Primary Educational Background among Project Managers

		Project success or failure				Total
		Successful	% Success	Failure	% Failure	
What best describes your educational background (if you've studies more than one area, choose the field where you have spent the most time or effort)?	Arts	1	100	0	0	1
	Business	8	100	0	0	8
	Computer/Information Sciences	15	78.9	4	21.1	19
	Engineering	7	70	3	30	10
	Mathematics	2	100	0	0	2
	Natural Sciences (such as Biology, Chemistry, Physics)	1	100	0	0	1
	Social Sciences (such as Sociology, Psychology, Political Science)	7	100	0	0	7
	Other	0	0	1	100	1
Total		41	83.7	8	16.3	49

Figure 20 shows that those projects that were most successful involved people from a Computer and Information Sciences education background.

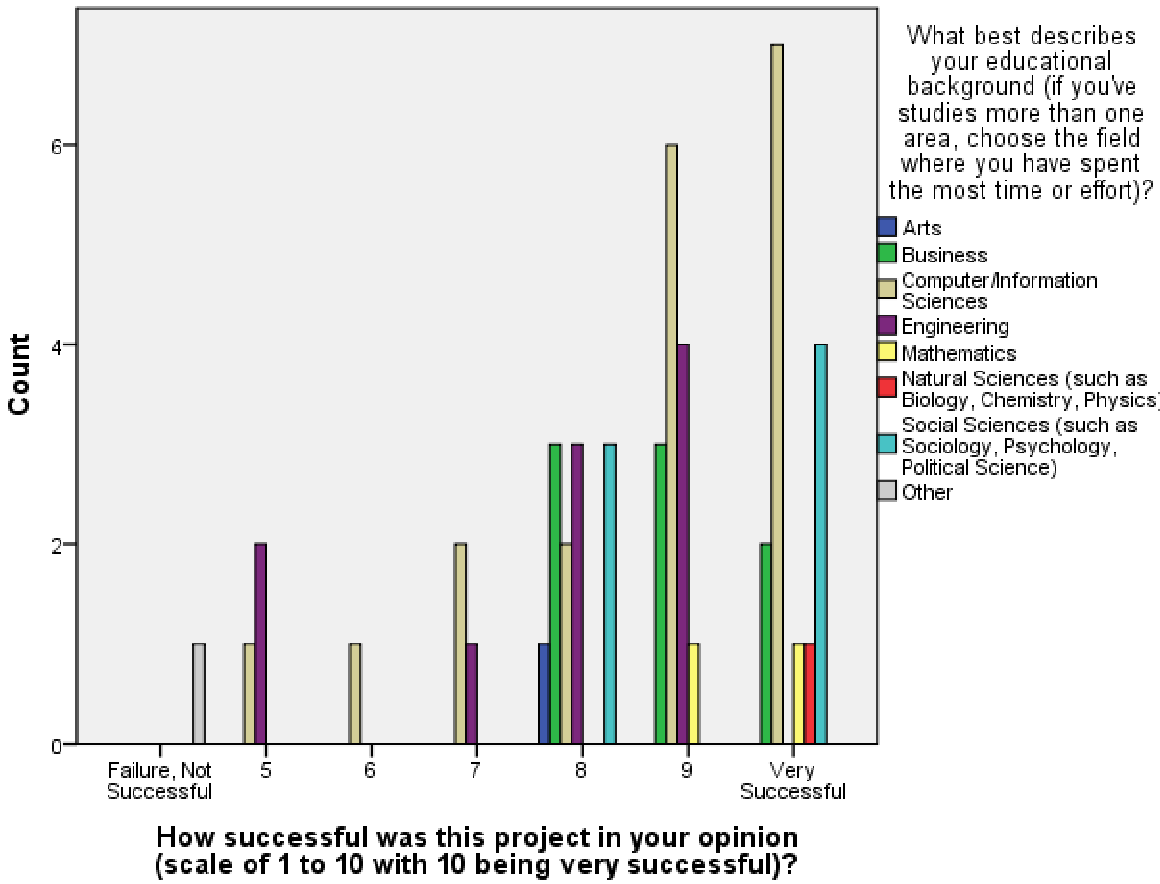

Figure 20 Project Success Compared to Primary Educational Background Among Project Managers

<u>Requirements engineers</u> Most requirements engineeers had a background in Computer/Information Science. Among requirements engineers, 57.5% of respondents had Computer/Information Science background. The second largest group was Business. Of those with a Computer/Informattion Science background, 73.9% worked on successful projects. Of those with a Business background, 54.5% worked on successful projects. This indicates a requirements engineer with a background in Computer/Information Science may help a project to be more successful. Table 31 provides the requirements engineers responses.

Table 31 Project Success Compared to Primary Educational Background among Requirements Engineers

		Project success or failure				
		Successful	% Success	Failure	% Failure	Total
What best describes your educational background (if you've studies more than one area, choose the field where you have spent the most time or effort)?	Arts	2	100	0	0	2
	Business	6	54.5	5	45.5	11
	Computer/Information Sciences	17	73.9	6	26.1	23
	Engineering	1	50	1	50	2
	Mathematics	0	0	0	0	0
	Natural Sciences (such as Biology, Chemistry, Physics)	0	0	0	0	0
	Social Sciences (such as Sociology, Psychology, Political Science)	1	50	1	50	2
	Other	0	0	0	0	0
Total		27	67.5	13	32.5	40

Figure 21 shows that those with a Computer/Information Science background mostly worked on more successful projects. It may, therefore, benefit a project to assign someone with a Computer/Information Science background to the requirements engineer role. Those with a Business background, the next most prevalent category, had a lower percentage of success within their projects.

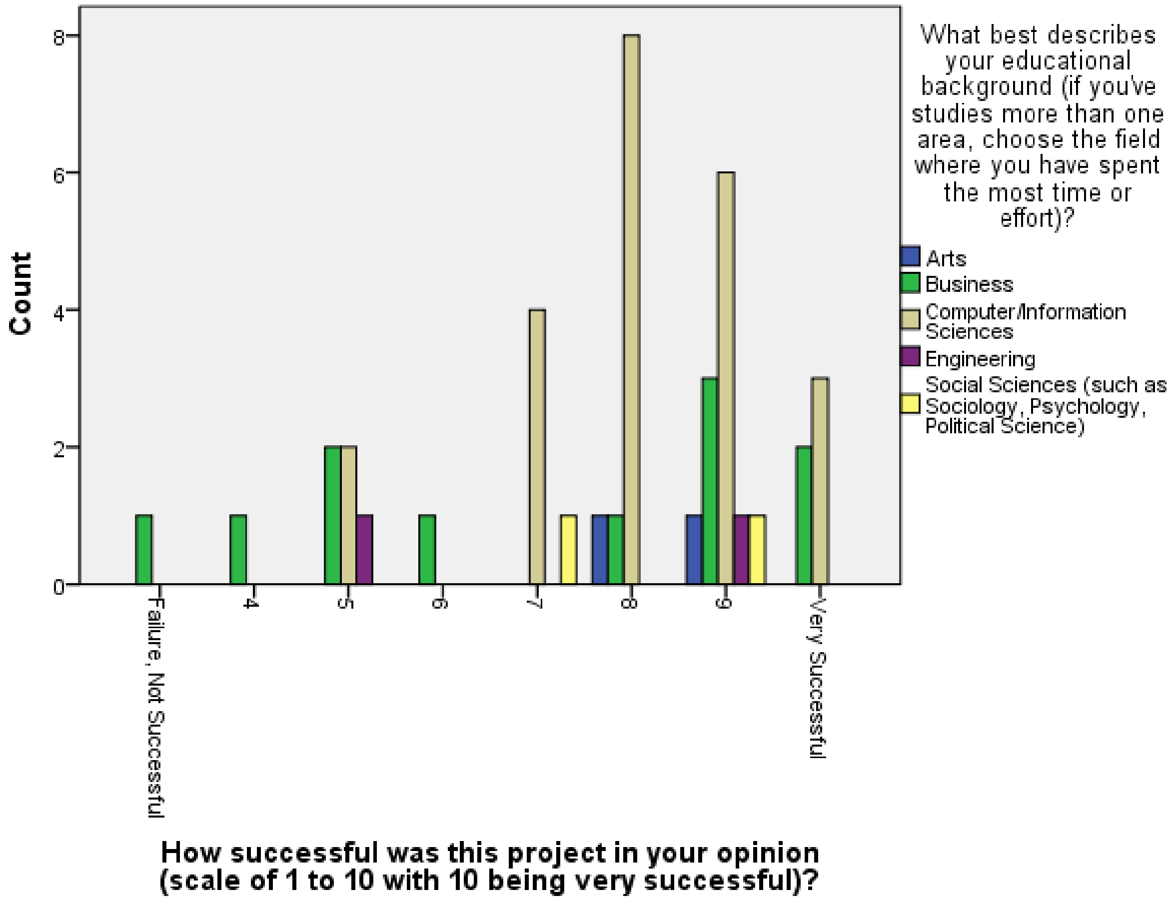

Figure 21 Project Success Compared to Primary Educational Background Among Requirements Engineers

Summary It may benefit a project to select a project manager with a Business, Social Science, or Computer and Information Science education background. Projects were also more successful with a requirements engineer with a Computer and Information Science background. However, the null hypothesis cannot be rejected and so it cannot be determined that education directly impacts project success.

PM10 / RE9: Do you hold any of the following certifications (choose all that apply)?

Only the Project Management Professional (PMP) certification was prevalent in the data (37.9%). Most respondents did not have any certification at all. Of those with PMP, 83.3% worked on successful projects. Of those with no certification, 68.3% worked on successful projects. This shows that having the PMP may increase project success. Table 32 shows the responses compared to success and failure.

Table 32 Project Success Compared to Certifications Held

		Project success or failure				
		Successful	% Success	Failure	% Failure	Total
Do you hold any of the following certifications (choose all that apply)?	Certified Associate of Project Management (CAPM)	1	100	0	0	1
	Project Management Professional (PMP)	30	83.3	6	16.7	36
	Prince2 (any level)	2	100	0	0	2
	Certified Business Analysis Professional (CBAP)	1	100	0	0	1
	Certified Software Quality Engineer (CSQE)	2	100	0	0	2
	Information Technology Infrastructure Library (ITIL)	3	75	1	25	4
	Certified SCRUM Master (CSM)	1	100	0	0	1
	Microsoft Certification(MCSE, MCSD, MCP, MCTS)	2	66.7	1	33.3	3
	Cisco Certification (CCNP, CCVP)	1	100	0	0	1
	IEEE Certified Software Development Professional	0	0	1	100	1
	Oracle Certification	1	100	0	0	1
	Certified Information Systems Security Professional (CISSP)	1	100	0	0	1
	None	28	68.3	13	31.7	41

No correlations could be determined using individual certifications. Few or no data points were provided for some of the certifications. Data were grouped to compare those who had any of these certifications to those who had none. Table 33 below shows the grouped data.

Table 33 Those With Certifications and Those Without Certifications Compared to Project Success

		Project success or failure				
		Successful	% Success	Failure	% Failure	Total
Do you hold any of the following certifications (choose all that apply)?	Hold at least one certification	45	83.3	9	16.7	54
	No certifications held	28	68.3	13	31.7	41

With data grouped in this way, there are 2 degrees of freedom. The Fischer Exact test was used to determine independence. This yielded a p-value of 0.09349 which suggests that having certifications may increase project success.

Project managers Among project managers, 53.6% had the Project Management Professional (PMP) certification. The next largest group (32.1%) did not have any certification. Of those with the PMP, 86.7% worked on successful projects. Of those without any certification, 77.8% worked on successful projects. This supports that a project manager with a PMP may increase success. Table 34 shows the project managers responses.

Table 34 Project Success Compared to Certifications Held among Project Managers

		Project success or failure				
		Successful	% Success	Failure	% Failure	Total
Do you hold any of the following certifications (choose all that apply)?	Project Management Professional (PMP)	26	86.7	4	13.3	30
	Certified Software Quality Engineer (CSQE)	2	100	0	0	2
	Information Technology Infrastructure Library (ITIL)	2		1		3
	Certified SCRUM Master (CSM)	1	100	0	0	1
	Microsoft Certification(MCSE, MCSD, MCP, MCTS)	1	100	0	0	1
	Oracle Certification	1	100	0	0	1
	Certified Information Systems Security Professional (CISSP)	1	100	0	0	1
	None	14	77.8	4	22.2	18

Requirements engineers Among requirements engineers, 59% held none of these certifications. The next largest group had the PMP certification (15.4%). Of those with the certification, 66.7% worked on projects rated as 8, 9, or 10. Of those without a certification, 60.9% worked on projects rated as 8, 9, or 10. Requirements engineers with the PMP may be slightly more likely to have a successful project. Table 35 shows the requirements engineers responses.

Table 35 Project Success Compared to Certifications Held among Requirements Engineers

		Project success or failure				Total
		Successful	% Success	Failure	% Failure	
Do you hold any of the following certifications (choose all that apply)?	Certified Associate of Project Management (CAPM)	1	100	0	0	1
	Project Management Professional (PMP)	4	66.7	2	33.3	6
	Prince2 (any level)	2	100	0	0	2
	Certified Business Analysis Professional (CBAP)	1	100	0	0	1
	Information Technology Infrastructure Library (ITIL)	1	100	0	0	1
	Microsoft Certification(MCSE, MCSD, MCP, MCTS)	1	50	1	50	2
	Cisco Certification (CCNP, CCVP)	1	100	0	0	1
	IEEE Certified Software Development Professional	0	0	1	100	1
	Oracle Certification	1	100	0	0	1
	None	14	60.7	9	39.3	23

Summary The certification most prevalent among respondents was the Project Management Professional (PMP). It may increase project success to hold any certification (not just PMP). Those with certifications did have higher success than those who did not have certifications.

PM12 / RE15: Did you have domain expertise when the project began?

Respondents were asked as to their level of expertise within project's application domain. 30.3% of respondents had little or no expertise in the domain when the project began. Among respondents 69.7% did have at least some expertise in the domain. Of those with little or no domain expertise, 74.1% worked on successful projects. Of those with some domain expertise, 77.8% worked on successful projects. Of those with significant domain expertise, 78.9% worked on successful. This shows a trend that those with more domain expertise work on more successful projects. However, this does not hold true for experts in the domain as this group only had 74.1% who worked on successful projects. This shows it may be beneficial to have some or significant domain knowledge when the project begins. Table 36 shows the responses compared to project success and failure.

Table 36 Project Success Compared to Domain Expertise

		Project success or failure				
		Successful	% Successful	Failure	% Failure	Total
Did you have domain expertise when the project began?	Little or no domain expertise	20	74.1	7	25.9	27
	Some domain expertise	28	77.8	8	22.2	36
	Significant domain expertise	15	78.9	4	21.1	19
	Expert in the domain when the project began	5	71.4	2	28.6	7
Total		68	76.4	21	23.6	89

Figure 22 shows the trend of some and significant domain knowledge in the data.

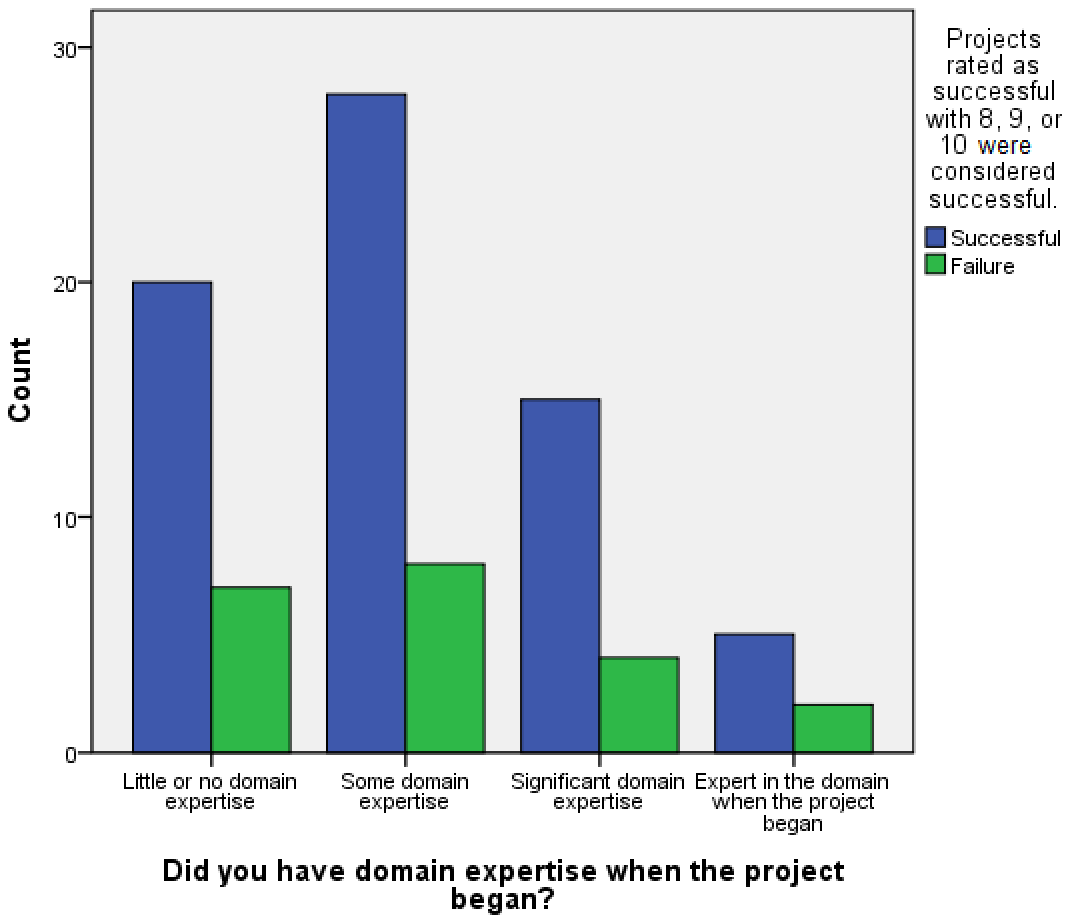

Figure 22 Project Success Compared to Domain Expertise

The data was not statistically significant. A χ^2 value of 7.815 would be needed to reject the null hypothesis with 95% confidence. The data yielded a χ^2 value of 0.283. The p-value is 0.963 which is inconclusive. This means that domain knowledge does not impact project success. Table 37 contains the results of the chi-square analysis.

Table 37 Test of Null Hypothesis of Project Success Compared to Domain Expertise

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.283[a]	3	.963
Likelihood Ratio	.280	3	.964
Linear-by-Linear Association	.013	1	.910
N of Valid Cases	89		

a. 2 cells (25.0%) have expected count less than 5. The minimum expected count is 1.65.

Project managers Among project managers, 30.6% had little or no domain experience. 69.4% of Project Manger had at least some domain knowledge. Of those with little of no domain expertise, 80% worked on successful projects. Of those with some domain expertise, 85% worked on successful projects. Of those with significant domain expertise, 77.7% worked on successful projects. Of those who were experts in the domain, 100% worked on successful projects. This indicates it may be benficial for the Project Manger to have more knowledge of the domain when the project begins. Table 38 contains the project managers responses.

Table 38 Project Success Compared to Domain Expertise among Project Managers

		Project success or failure				Total
		Successful	% Successful	Failure	% Failure	
Did you have domain expertise when the project began?	Little or no domain expertise	12	80	3	20	15
	Some domain expertise	17	85	3	15	20
	Significant domain expertise	7	77.8	2	22.2	9
	Expert in the domain when the project began	5	100	0	0	5
Total		41	83.7	8	16.3	49

Figure 23 shows those with more domain expertise generally were more successful.

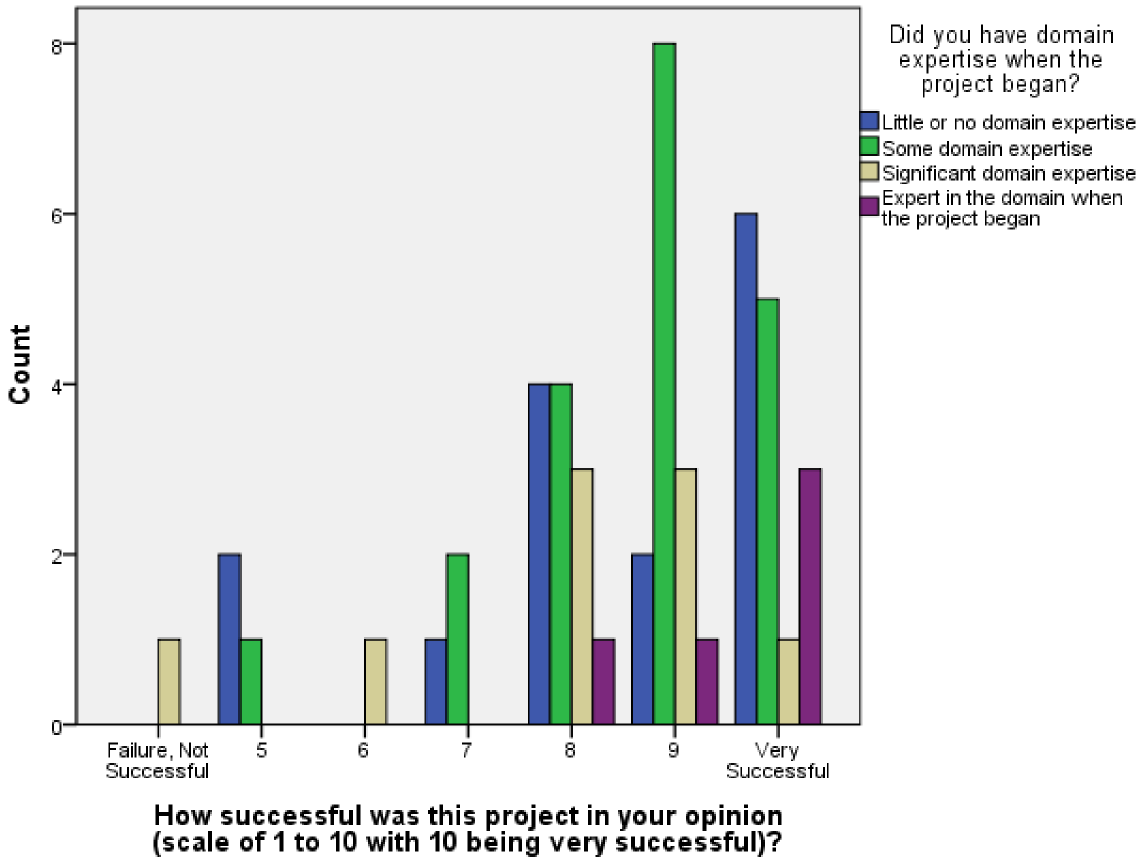

Figure 23 Project Success Compared to Domain Expertise Among Project Managers

Requirements engineers For requirements engineers, 30% had little or no domain expertise, 40% had some domain expertise, and 25% had significant domain expertise. For those with little or no domain expertise, 66.7% worked on successful projects. For those with some domain expertise, 68.8% worked on successful projects. For those with significant domain expertise, 80% worked on successful projects. This indicated the most effective requirements engineers may be those with significant domain expertise. Table 39 contains the requirements engineers responses.

Table 39 Project Success Compared to Domain Expertise Among Requirements Engineers

		Project success or failure				Total
		Successful	% Successful	Failure	% Failure	
Did you have domain expertise when the project began?	Little or no domain expertise	8	66.7	4	33.3	12
	Some domain expertise	11	68.8	5	32.2	16
	Significant domain expertise	8	80	2	20	10
	Expert in the domain when the project began	0	0	2	100	2
Total		27	67.5	13	32.5	40

Figure 24 shows that those with significant domain expertise are most highly clustered with more successful projects.

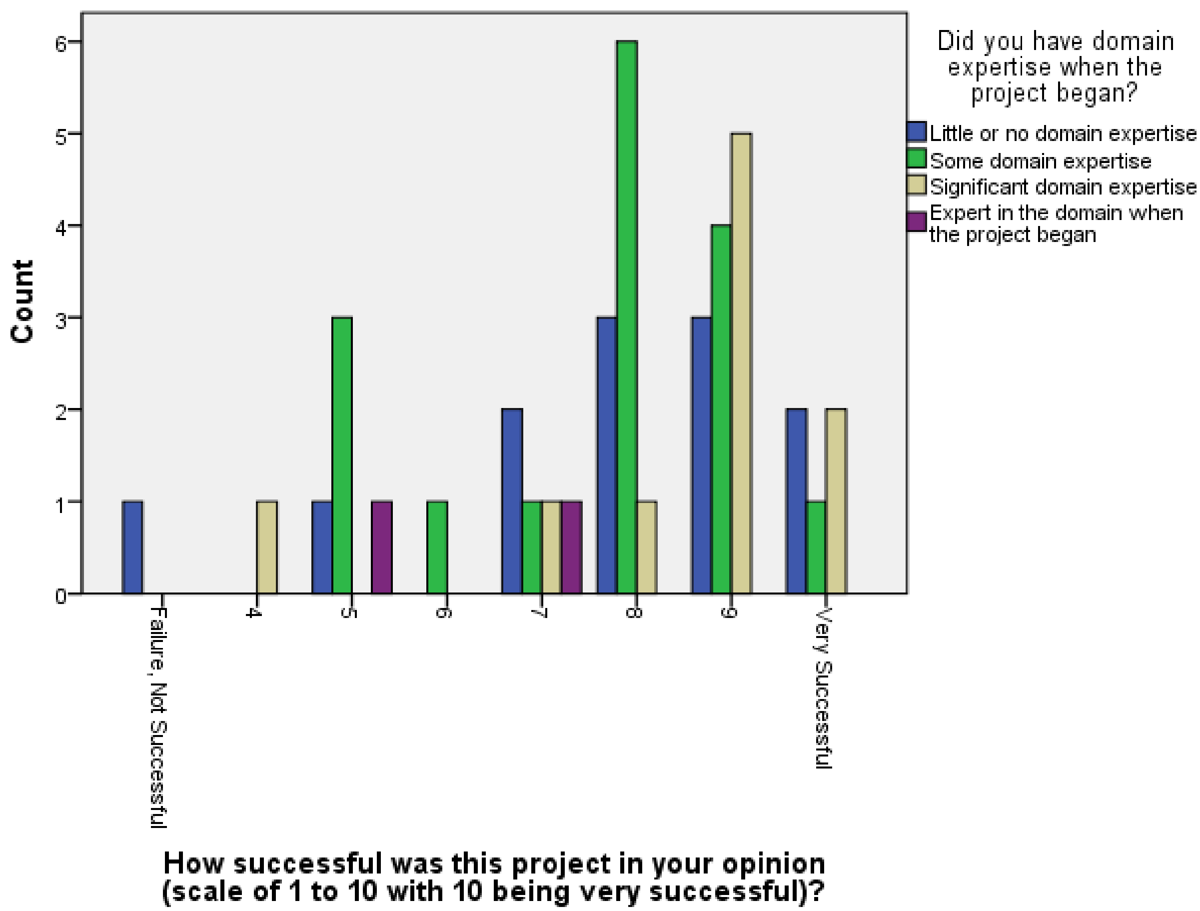

Figure 24 Project Success Compared to Domain Expertise Among Requirements Engineers

Summary For project managers, having some domain knowledge may improve the probability for project success. For requirements engineers, having significant domain knowledge may improve the probability for project success. However, the null hypothesis could not be rejected and so the level of domain knowledge cannot be shown to directly impact project success.

PM22 / RE25: What software development methodologies were used on the project (select all that apply)?

Respondents were asked which, if any, software development methodology were used in their project. Respondents could choose more than one methodology. The two most common methodologies were Incremental/Phased Waterfall and Waterfall. Of responses, 28.4% indicated Incremental/Phased Waterfall was used. Of responses, 23.9% indicated Waterfall was used. Of responses, 8.3% indicated they did not know the methodology used. Of Waterfall projects, 73% succeeded. Of Incremental/Phased Waterfall projects, 77.4% succeeded. Of projects using Rapid Application Development/Rapid Prototyping, 86.7% succeeded. This is the highest success rate among the methodologies included in the survey. Rapid Application Development/Rapid Prototyping may lead to more successful projects. Table 40 shows the responses compared to project success and failure.

Table 40 Project Success Compared to Software Development Methodologies

		Project success or failure				
		Successful	% Successful	Failure	% Failure	Total
What software development methodologies were used on the project (select all that apply)?	Waterfall	19	73.1	7	26.9	26
	Incremental / Phased Waterfall	24	77.4	7	22.6	31
	Application Development / Rapid Prototyping	13	86.7	2	13.3	15
	Spiral	4	66.7	2	33.3	6
	Agile	11	78.6	3	21.4	14
	None	6	75	2	25	8
	Don't Know	7	77.8	2	22.2	9
Total						109

Data were categorized into three groups: those who used a methodology, those who did not use a methodology, and those who did not know. No correlations could be identified between use of a methodology and project success. The p-value for this grouping, 0.7642, was inconclusive.

Project managers Project managers indicated that Waterfall and Incremental/Phased Waterfall were the most used methodologies. However, Rapid Application Development/Rapid Prototyping had 100% success when used on projects. Table 41 shows the project managers responses.

Table 41 Project Success Compared to Software Development Methodologies Reported by Project Managers

		Project success or failure				Total
		Successful	% Successful	Failure	% Failure	
What software development methodologies were used on the project (select all that apply)?	Waterfall	13	92.9	1	7.1	14
	Incremental / Phased Waterfall	20	95.2	1	4.8	21
	Application Development / Rapid Prototyping	8	100	0	0	8
	Spiral	1	100	0	0	1
	Agile	6	75	2	25	8
	None	4	80	1	20	5
	Don't Know	2	50	2	50	4
Total						56

Requirements engineers Requirements engineers also indicated that Waterfall and Incremental/Phased Waterfall were used the most. However, they report that only 50% of Waterfall projects succeeded. 40% of Incremental/Phased Waterfall projects succeeded. The most successful methodology among requirements engineers is Agile with 83.3% of projects successful. Table 42 shows the requirements engineers responses.

Table 42 Project Success Compared to Software Development Methodologies Among Requirements Engineers

		Project success or failure				
		Successful	% Successful	Failure	% Failure	Total
What software development methodologies were used on the project (select all that apply)?	Waterfall	6	50	6	50	12
	Incremental / Phased Waterfall	4	40	6	60	10
	Application Development / Rapid Prototyping	5	71.4	2	21.6	7
	Spiral	3	60	2	40	5
	Agile	5	83.3	1	16.7	6
	None	2	66.7	1	33.3	3
	Don't Know	5	100	0	0	5
Total						48

Summary Rapid prototyping was most successful in the full set of data and within project managers only. Requirements engineers reported Agile as the most successful project. Even though less successful, Incremental/Phased Waterfall and Waterfall were reported as most used by both groups. It may improve the probability for project success to use Application Development/Rapid Prototyping or Agile methodologies.

PM25 / RE27: What percent of the overall project time was devoted to gathering requirements?

All respondents were asked what percentage of the overall project time was allotted to gathering requirements. Other research has indicated that 27% of the project time being spent on requirements leads to more successful projects (Hoffman, 2001). For this question, respondents were able to provide a number and were not required to select from a list. This resulted in many different responses. The three that occurred most often were 15%, 20%, and 30% of the project time being spent on requirements. For projects that spent 15% and 20% of the project effort on requirements, 81.8% of the projects succeeded. For projects that spent 30% of the total project time on requirements, 85.7% of the projects succeeded.

This is the highest success among all the percentages of time spent on requirements. This concurs with other research that about 30% of project time should be spent on projects to increase the likelihood of project success. Table 43 lists the responses compared to project success.

Table 43 Project Success Compared to Percentage of Project Time Allotted to Gathering Requirements

		Project success or failure				
		Successful	% Successful	Failure	% Failure	Total
What percent of the overall project time was devoted to gathering requirements (number only with no formatting)?	0	1	50	1	50	2
	1	0	0	2	100	2
	4	1	100	0	0	1
	5	4	80	1	20	5
	7	0	0	1	100	1
	10	2	40	5	60	7
	15	7	77.8	2	22.2	9
	20	18	81.8	4	18.2	22
	25	5	83.3	1	16.7	6
	30	12	85.7	2	14.3	14
	35	3	100	0	0	3
	40	5	83.3	1	16.7	6
	45	1	100	0	0	1
	50	5	83.3	1	16.7	6
	60	1	100	0	0	1
	75	2	100	0	0	2
	90	1	100	0	0	1
Total		68	76.4	21	23.6	89

Figure 25 shows where the most number of successful projects spent 20% of the project effort on requirements.

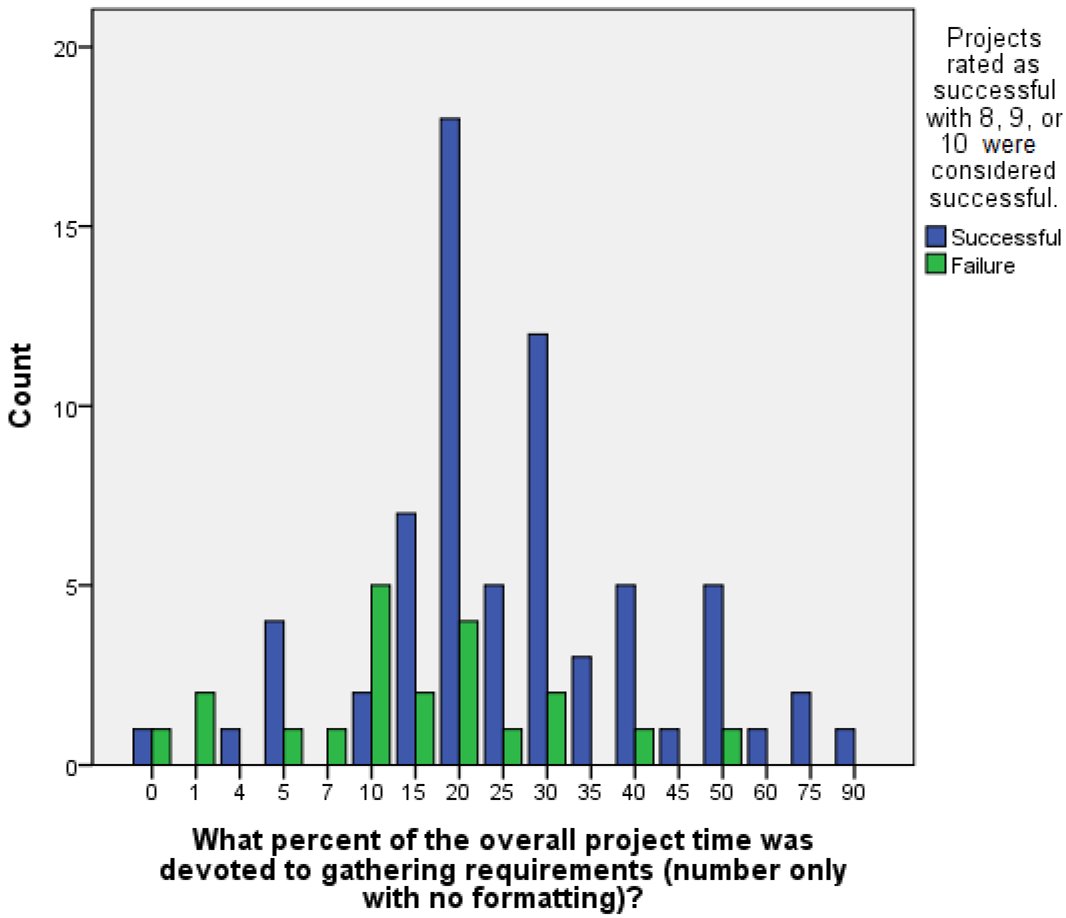

Figure 25 Project Success Compared to Percentage of Project Time Allotted to Gathering Requirements

Testing this data for statistical significance ($\chi^2 = 23.706$) shows that the null hypothesis can be rejected with 90% confidence (> 23.542), but not 95% confidence (< 26.296). The p-value, 0.096, suggests a correlation between the time allocated to requirements and project success. Table 44 contains the results of the chi-square analysis.

Table 44 Test of Null Hypothesis of Success Compared to Percentage of Project Time Allotted to Gathering Requirements

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	23.706[a]	16	.096
Likelihood Ratio	23.002	16	.114
Linear-by-Linear Association	7.188	1	.007
N of Valid Cases	89		

a. 29 cells (85.3%) have expected count less than 5. The minimum expected count is .24.

The highest concentration of successful projects devoted between 15% and 30% of overall project time to gathering requirements. Data were collected into three groups and analyzed again using the χ^2 test. Table 45 shows the data grouped and compared to project success.

Table 45 Allotted Requirements Time in Three Groups Compared to Project Success

		Project success or failure				Total
		Successful	% Successful	Failure	% Failure	
What percent of the overall project time was devoted to gathering requirements (number only with no formatting)?	0 - 10	8	44.4	10	55.6	18
	15-30	42	82.4	9	17.6	51
	> 30	18	90	2	10	20
Total		68	76.4	21	23.6	89

With the above grouping, the p-value, 0.0013, shows that allocating more time to requirements increases the likelihood for project success. There were 4.6 successful projects for each failed project among the projects with 15% to 30% of time allocated to requirements. The projects that had 15% or more time dedicated to requirements were twice as successful. There were 9 successful projects for each unsuccessful project among those that allocated more than 30% of project time to requirements. It is conclusive that the time allocated to requirements impacts project success.

Project managers Most project managers indicated they spent 20% and 30% of the project time on requirements. Projects spending 20% of the time on requirements succeeded 85.7% of the time. Projects spending 30% of the time on requirements had 100% of the projects rated as successful. Table 46 provides the project managers responses.

Table 46 Project Success vs. Percentage of Project Time Allotted to Gathering Requirements According to Project Managers

		Project success or failure				Total
		Successful	% Successful	Failure	% Failure	
What percent of the overall project time was devoted to gathering requirements (number only with no formatting)?	0	0	0	1	100	1
	1	0	0	1	100	1
	4	1	100	0	0	1
	5	3	100	0	0	3
	10	1	33.3	2	66.7	3
	15	5	83.3	1	16.7	6
	20	12	85.7	2	14.3	14
	25	4	100	0	0	4
	30	8	100	0	0	8
	35	1	100	0	0	1
	40	1	100	0	0	1
	45	1	100	0	0	1
	50	3	75	1	25	4
	75	1	100	0	0	1
Total		41	83.7	8	16.3	49

Figure 26 shows that projects spending 20% of the time on requirements mostly resulted in projects rated at 9. Projects spending 30% of time on requirements mostly resulted in projects rated at 10. Spending more time on requirements, up to 30%, can increase project success.

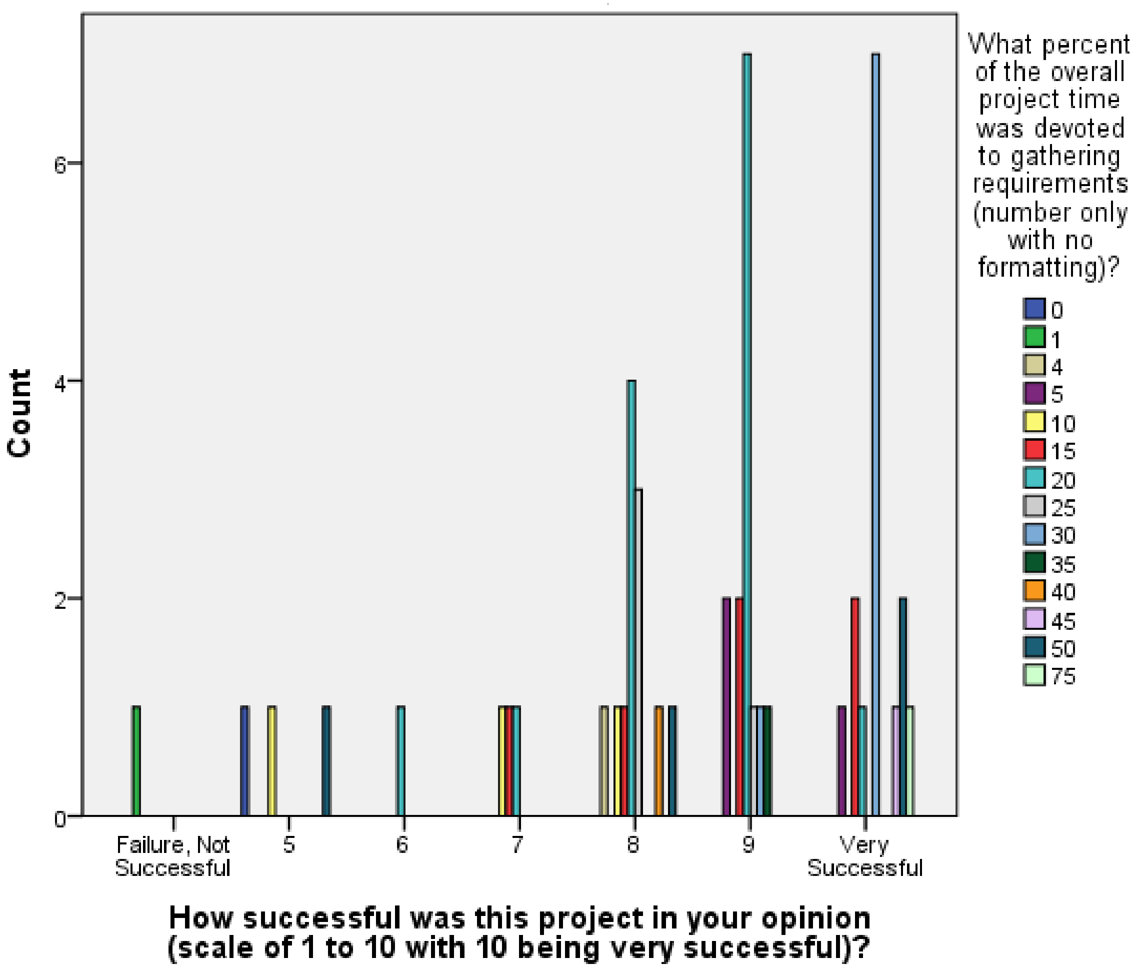

Figure 26 Project Success vs. Percentage of Project Time Allotted to Gathering Requirements According to Project Managers

Requirements engineers Requirements engineers also reported that most frequently, 20% or 30% of time was spent on requireements. Of the projects spending 20% of the time on requirements, 75% succeeded. For projects spending 30% of the time on requirements, 66.7% of the projects succeeded. While the data from the requirements engineers does not show that more time on requirements can increase project success, it still indicates that 20-30% of project time should be spent on requirments to increase success. Table 47 shows the requirements engineers responses.

Table 47 Project Success Compared to Percentage of Project Time Allotted to Gathering Requirements According to Requirements Engineers

		Project success or failure				
		Successful	% Successful	Failure	% Failure	Total
What percent of the overall project time was devoted to gathering requirements (number only with no formatting)?	0	1	100	0	0	1
	1	0	0	1	100	1
	5	1	50	1	50	2
	7	0	0	1	100	1
	10	1	25	3	75	4
	15	2	66.7	1	33.3	3
	20	6	75	2	25	8
	25	1	50	1	50	2
	30	4	66.7	2	33.3	6
	35	2	100	0	0	2
	40	4	80	1	20	5
	50	2	100	0	0	2
	60	1	100	0	0	1
	75	1	100	0	0	1
	90	1	100	0	0	1
Total		27	67.5	13	32.5	40

Figure 27 shows that, similarly to Project Manger responses, of the projects rated as a 9, most spent 30% of the project time on requriements. Most of the projects rated as 10 on the success scale also spent 30% of the project time on requirements.

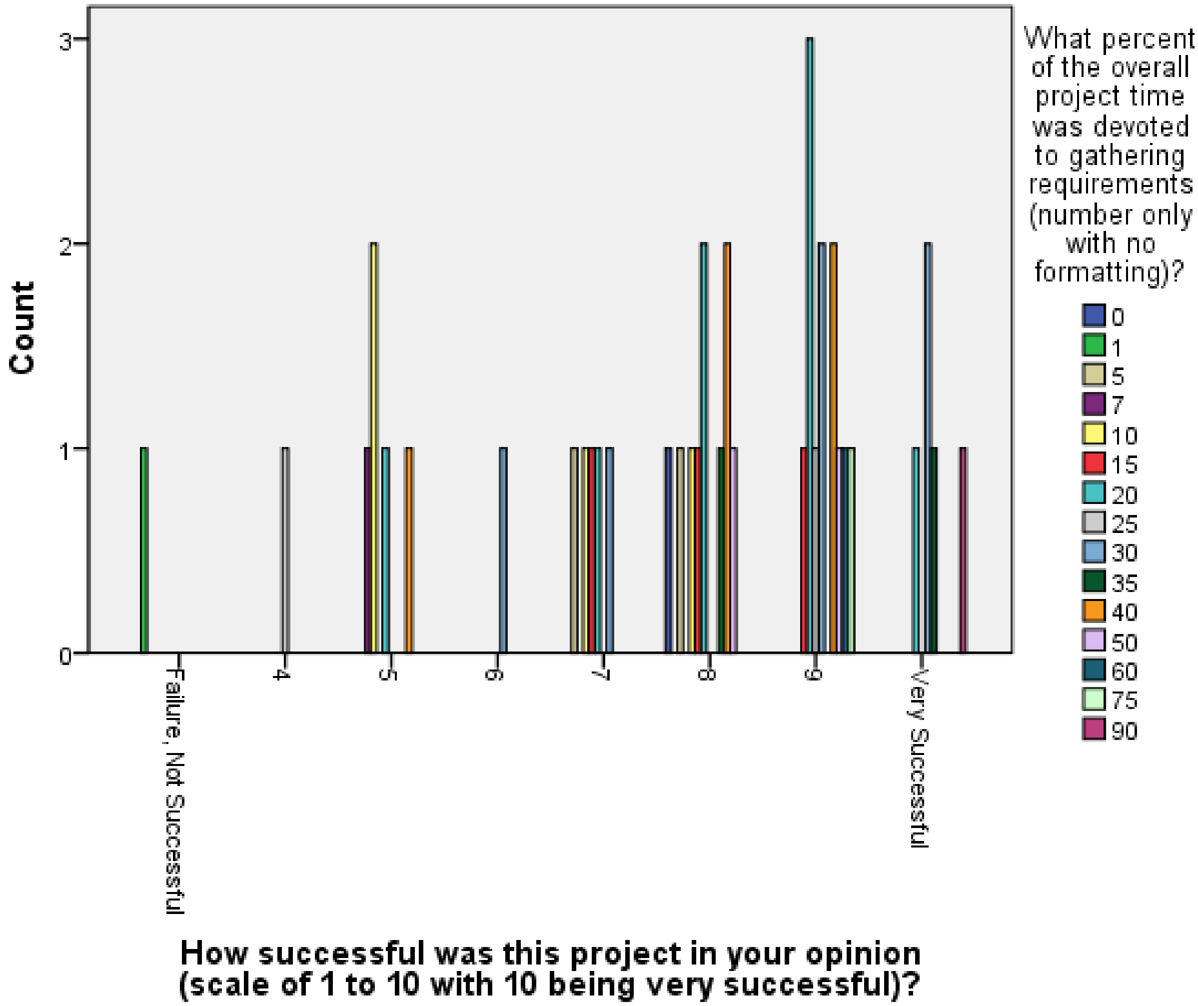

Figure 27 Project Success Compared to Percentage of Project Time Allotted to Gathering Requirements According to Requirements Engineers

Summary. The amount of time spent on requirements directly impacts project success. More projects succeeded among those that allocated higher amounts of time to project success. The increase in project success could be identified with those projects that had 15% or more of overall project time allocated to requirements.

RE28: How adequate was the amount of time planned for requirements gathering on the project?

This question was only posed to the requirements engineers. Since requirements engineers would have been responsible for these tasks, the question was to determine if they were given the time needed for these tasks. This was to assess whether requirements engineers felt they were given adequate time in the project schedule for requirements gathering. Of the responses, 62.5% felt they were given adequate or very adequate time to gather requirements. Only 10% indicated the time was inadequate or never scheduled. All projects rated as a 10 (most successful) had adequate or very adequate time allocated. For projects rated at 9, 91.7% of the projects had adequate or very adequate time allocated. At a project success rating of 8, only 50% of the projects were given adequate or very adequate time and 50% were given somewhat adequate time. This indicates that if a requirements engineer feels the time allotted is less than adequate or there is no planned amount of time for requirements, project success may be affected. Table 48 provides the responses compared to project success.

Table 48 Project Success Compared to Adequacy of Time Planned for Requirements Gathering

		Project success or failure				Total
		Successful	% Successful	Failure	% Failure	
How adequate was the amount of time planned for requirements gathering on the project?	Very Adequate	6	75	2	25	8
	Adequate	15	88.2	2	11.8	17
	Somewhat Adequate	6	54.5	5	45.5	11
	Inadequate	0	0	3	100	3
	There was no plan/schedule around requirements	0	0	1	100	1
Total		27		13		40

Figure 28 shows that the more successful projects have adequate to very adequate time allocated for gathering requirements.

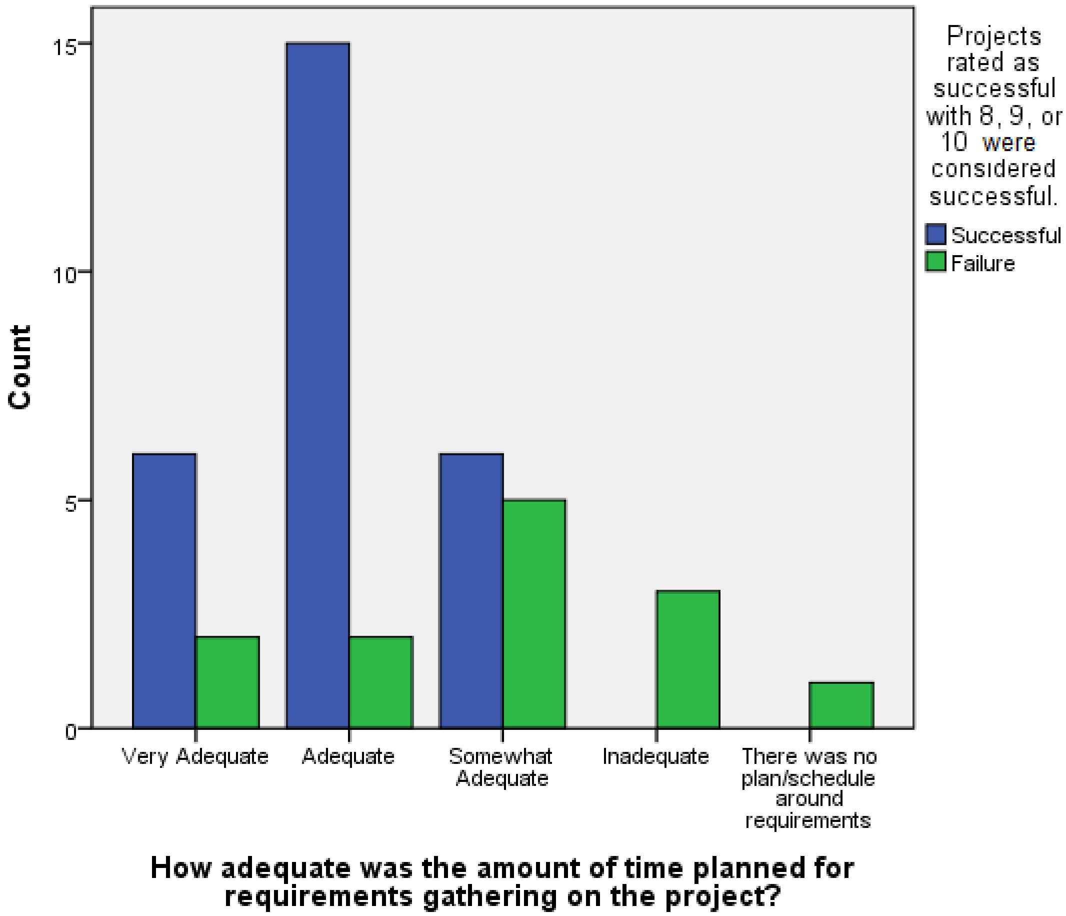

Figure 28 Project Success Compared to Adequacy of Time Planned for Requirements Gathering

These data were analyzed for statistical significance. The null hypothesis was rejected. A χ^2 value of 11.668 is needed to reject the null hypothesis with 98% confidence. The χ^2 value from the data is 12.686 which is greater than 11.668 and therefore the null hypothesis can be rejected. The p-value is, 0.01,3 shows that adequacy of requirements time is directly related project success. Table 49 provides the results of the chi-square analysis.

Table 49 Test of Null Hypothesis of Project Success Compared to Adequacy of Time Planned for Requirements Gathering

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	12.686[a]	4	.013
Likelihood Ratio	13.976	4	.007
Linear-by-Linear Association	8.011	1	.005
N of Valid Cases	40		

a. 6 cells (60.0%) have expected count less than 5. The minimum expected count is .33.

Summary With 98% confidence, having adequate time to plan requirements will increase the probability for project success. Having an inadequate amount of time or no plan at all for requirements can lead to project failure.

PM30 / RE29: Were any formal methods for gathering requirements followed on the project?

Respondents were asked what, if any, standards they used to gather requirements on their projects. Respondents could select more than one standard. Of the responses, 46.1% used a standard developed internally in their organization and 49.4% used no standard at all. For those using an internal standard, 87.8% of the projects succeeded. For those projects not using a standard, only 65.9% of the projects succeeded. Additionally, those that used the IIBA standard had all projects rated as a 9. This indicates that selecting a standard to use can increase project success. Table 50 shows the responses compared to project success.

Table 50 Project Success Compared to Standards for Gathering Requirements

		Project success or failure				Total
		Successful	% Successful	Failure	% Failure	
Were any formal methods for gathering requirements followed on the project?	IIBA Standards	3	100	0	0	3
	IEEE Standards	1	33.3	2	66.7	3
	Internal Standard	36	87.8	5	12.2	41
	None	39	72.2	15	27.8	54
Total		79	78.2	22	21.8	101

The χ^2 test with this data yielded a p-value of 0.0673. This suggests a relationship between standards and project success, but is not conclusive.

Project managers Project managers indicated that internal standards were used most or no standard at all (49% of responses for each). The Project Manger responses also reflect that the internal standard had 87.5% of projects rated as 8, 9, or 10. When no standard was used, only 79.2% of projects were rated at 8, 9, or 10. This supports that having a standard in place can increase success. Table 51 contains the project managers responses.

Table 51 Project Success Compared to Standards for Gathering Requirements According to Project Managers

		Project success or failure				Total
		Successful	% Successful	Failure	% Failure	
Were any formal methods for gathering requirements followed on the project?	IIBA Standards	3	100	0	0	1
	IEEE Standards	1	0	1	100	1
	Internal Standard	19	79.2	5	20.8	24
	None	21	87.5	15	12.5	24
Total		27	67.5	13	32.5	44

Requirements engineers Requirements engineers indicated that no standard was used 50% of the time and an internal standard 42.5% of the time. When the internal standard was used, 88.2% of the projects were rated as 8, 9, or 10. Only 50% of projects were rated as 8, 9, or 10 when no standard was used. This further supports that a standard increases project success. Table 52 contains the requirements engineers responses.

Table 52 Project Success Compared to Standards for Gathering Requirements According to Requirements Engineers

		Project success or failure				
		Successful	% Successful	Failure	% Failure	Total
Were any formal methods for gathering requirements followed on the project?	IIBA Standards	2	100	0	0	2
	IEEE Standards	1	33.3	2	66.7	2
	Internal Standard	15	88.2	2	11.9	17
	None	10	50	10	50	20
Total		27	67.5	13	32.5	44

Summary Using a standard may increase the likelihood of project success. The highest concentration of successful projects was those that used an internal standard. The projects using an internal standard were more successful than those projects which did not use a standard, but using a standard does not guarantee project success.

PM31 / RE30: Were any of the following techniques used to gather requirements on the project (select all that apply)?

Respondents were asked what techniques where used on the projects to gather requirements. Respondents could select more than one technique. Of responses, 28.2% indicated use cases, 26.8% used prototyping, 16.9% used JAD Sessions, 16.9% didn't use any of these techniques, and 11.3% used modeling. Of these techniques, 91.6% of projects that used JAD Sessions succeeded. Of projects that used use cases, 87.5% succeeded. Of projects using prototyping, 81.6% succeeded. Of projects that used modeling, 75% succeeded. Those projects that used none these techniques succeeded only 58.3% of the time. Of these techniques, JAD sessions may be the most effective to achieve project success. There is also a significant increase in success when at least one method is used as compared to none at all. Table 53 provides the responses compared to project success.

Table 53 Project Success Compared to Requirements Gathering Techniques

		Project success or failure				Total
		Successful	% Successful	Failure	% Failure	
Were any of the following techniques used to gather requirements on the project (select all that apply)?	Prototyping	31	81.6	7	18.4	38
	JAD Sessions	22	91.7	2	8.3	24
	Modeling	12	75	4	25	16
	Use Cases	35	87.5	5	12.5	40
	None of these	14	58.3	10	41.7	24
Total		114	80.3	28	19.7	142

This data were analyzed for statistical significance. The p-value, 0.0276, shows that using at least one of these requirements gathering techniques does increase project success.

Project managers Project managers indicated that Prototyping and Use Cases were the most prevalent techniques - 31.0% used use cases and 29.9% used prototyping. JAD sessions are shown to be most effective for project success with 94.1% of projects using JAD sessions being rated as 8, 9, or 10. Table 54 shows the project managers responses.

Table 54 Project Success Compared to Requirements Gathering Techniques According to Project Managers

		Project success or failure				
		Successful	% Successful	Failure	% Failure	Total
Were any of the following techniques used to gather requirements on the project (select all that apply)?	Prototyping	22	84.6	4	15.4	26
	JAD Sessions	16	94.2	1	5.8	17
	Modeling	7	77.8	2	22.2	9
	Use Cases	25	92.6	2	7.4	27
	None of these	4	50	4	50	8
Total		74	85.1	13	14.9	87

<u>Requirements engineers</u> Requirements engineers indicated that none of these techniques were used 29.1% of the time. Use cases were employed 23.6% of the time. Prototypes were used 21.8% of the time. The techniques are used at a different frequency than indicated by the project managers. However, the data from requirements engineers show that JAD Sessions are still most effective. Of projects using JAD sessions, 85.7% succeeded. Table 55 shows the requirements engineers responses.

Table 55 Project Success Compared to Requirements Gathering Techniques According to Requirements Engineers

		Project success or failure				
		Successful	% Successful	Failure	% Failure	Total
Were any of the following techniques used to gather requirements on the project (select all that apply)?	Prototyping	9	75	3	25	12
	JAD Sessions	6	85.7	1	14.3	7
	Modeling	5	71.4	2	28.6	7
	Use Cases	10	76.9	3	23.1	13
	None of these	10	62.5	6	37.5	16
Total		40	72.7	15	27.3	55

Summary The techniques used to gather requirements do impact project success. JAD sessions resulted in the most successful projects. Use cases had the second highest success level followed by Prototyping. For those projects that did not use any of these techniques, almost 30% fewer succeeded.

PM32 / RE31: Briefly, what do you think was most beneficial to the success of the project (optional)?

The most respondents indicated that good cooperation between the development team and the client was essential to project success. The next most frequently mentioned point was that a project must have good requirements to succeed. Figure 29 shows a graph of the responses.

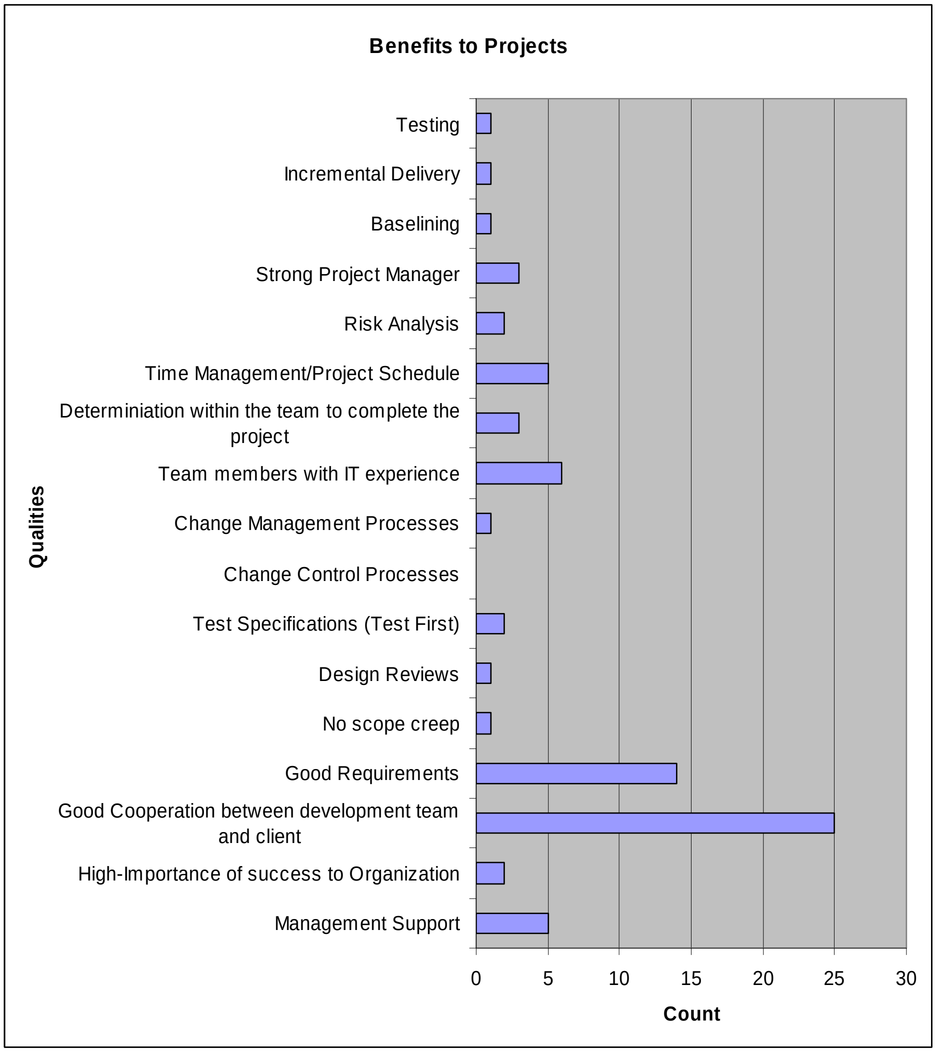

Figure 29 Qualities Most Beneficial to Projects

PM33 / RE32: Briefly, what do you think was most detrimental to the project (optional)?

Where good collaboration between the development team and client and good requirements can lead to a successful project, respondents indicated problems in either of these areas are most detrimental to projects. Figure 30 shows a graph of these responses.

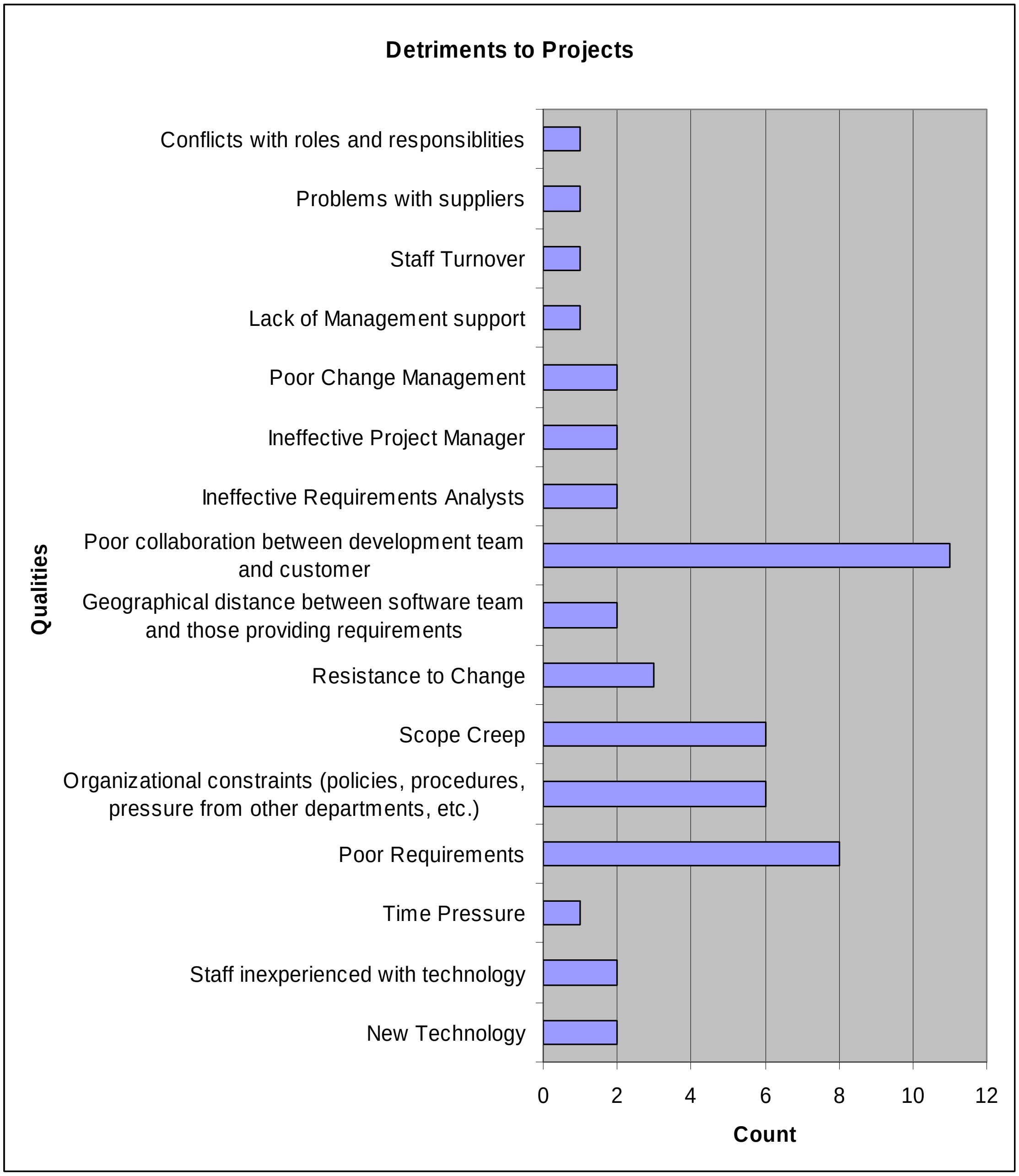

Figure 30 Qualities Most Detrimental to Projects

PM10 / RE9 and PM31 / RE30: Does having a certification lead to more formal requirements analysis?

Respondents were asked what certifications they or the project team members who worked on requirements held. They were also asked what requirements techniques were used in their projects. These values were compared to determine if any particular certification(s) resulted in requirements techniques being used more. There may be a connection between the PMP and the use of requirements techniques. Those with a PMP indicated they are using requirements techniques more frequently. Only those without any certifications indicated that they were using requirements techniques with greater frequency. However, having the PMP did not ensure the techniques were used as 7 responses were recorded that none of the techniques were used. Table 56 shows the certifications compared to the requirements techniques used.

Table 56 Impact of Certifications on Requirements Techniques Used

		Requirements Techniques					
		Prototyping	JAD Sessions	Modeling	Use Cases	None	Total
Certifications	Certified Associate of Project Management (CAPM)	0	0	1	1	0	
	Project Management Professional (PMP)	17	10	5	19	7	58
	Prince2 (any level)	0	0	1	0	1	2
	Certified Business Analysis Professional (CBAP)	1	1	1	1	0	4
	Certified Software Quality Engineer (CSQE)	1	1	1	1	1	5
	Information Technology Infrastructure Library (ITIL)	1	1	0	2	1	5
	Certified SCRUM Master (CSM)	1	1	1	1	0	4
	Microsoft Certification(MCSE, MCSD, MCP, MCTS)	1	0	0	0	2	3
	Cisco Certification (CCNP, CCVP)	0	0	0	0	1	1
	IEEE Certified Software Development Professional (CSDP)	0	0	1	0	0	1
	Oracle Certification	1	1	0	1	0	3
	Certified Information Systems Security Professional (CISSP)	0	0	0	1	0	1
	None	16	10	7	17	13	63
	Total	39	25	18	44	26	152

A χ^2 analysis of this data yielded a p-value of 0.4503 which is inconclusive. Therefore, certifications do not determine whether requirements techniques are used.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE WORK

Conclusions

Several characteristics of successful projects have been identified that can increase the probably of project success. These findings should enable project managers and management to identify qualified staff for requirements engineering tasks and to guide their staff in finding effective ways to develop requirements engineering skills. These findings also suggest sound practices to follow in gathering requirements. Project managers can monitor the requirements process to make sure these practices are followed to increase the likelihood for project success.

Successful projects do need strong project managers. Project managers with more professional work experience—ideally, with at least 5 years' Information Technology experience—are more successful. This may be due to their having been exposed to more challenges and having developed strategies to handle those challenges. Project managers are most successful when they have served as project manager on more than 10 projects. This shows that more project management experience increases the likelihood for project success.

When assigning project managers to projects, project managers with more project management experience should be assigned to projects that are most critical. Those with the Project Management Professional (PMP) were most successful. PMP certification demonstrates an understanding of the Project Management Body of Knowledge (PMBOK) as well as a minimum level of project management experience. The PMBOK is regarded as a guide to best practices for project management. Those who have the PMP can effectively apply these practices in management settings. Their experience also prepares them to handle challenges and lead teams to succeed. The survey involved project managers and requirements engineers. Of the respondents, 60 were project managers and 56 were requirements engineers. This means half the responses were from project managers. The requirements engineers balanced the responses from the project managers. If project management experience and the PMP increased success only according to project managers, responses from requirements engineers would have cancelled project manager responses. This shows that more project management experience and the PMP were beneficial not just among project managers, but with most professionals.

Requirements engineers with at least 5 years of professional experience are more successful. This indicates that individuals cannot immediately step into the requirements engineer role. When more requirements engineers are needed, it may be best for new requirements engineers to assist more experienced requirements engineers. This will give new requirements engineers an example to follow. It will also introduce the new requirements engineers to techniques for requirements gathering and strategies for applying them for gathering requirements. When assigning a requirements engineer to a project, requirements engineers with more experience should be assigned to the most critical projects to increase chances for success.

The more experience the requirements engineer has in the Information Technology field, the more successful the project will be. This may be because with more experience requirements engineers gain exposure to more technologies and solutions to problems. These experiences can then be applied in the course of discovering requirements and meeting new challenges. Requirements engineers were more successful after serving as requirements engineer on more than 25 projects. This further implies that exposure to more situations increases a requirements engineer's ability to provide high quality requirements and increase the likelihood for project success.

Those who work on successful projects may be more likely to be promoted to higher management positions. Those who had served in higher management positions reported a high project success rate. Selecting qualified people for requirements engineering roles will increase the chances of success, which can help an organization to succeed and may help the careers of everyone on the project.

Requirements engineers are most effective when they have served in project management, business analysis, and software engineering roles. Serving in all these roles provides a wide range of experiences to the requirements engineer. It affords an understanding of the importance of scope, schedule, and budget to a project. Experience in project management should motivate a requirements engineer to clearly define the work before starting. The requirements engineer would make sure the work is within any scope, schedule, or budget constraints. The engineer would also understand how business operates. As business leaders and users relate their needs, the requirements engineer should find it easier to understand these needs and their importance to the business and to guide users to a solution to meet their needs.

Requirements engineers are most effective when they have a bachelor's degree in the field of Computer and Information Sciences. This indicates it is best to draw on the technical field to fill the requirements engineer role. While a requirements engineer will need business knowledge to succeed, a solid technical background will facilitate success. Some writings on project management have claimed that it is not necessary to use someone with a technical background to gather requirements. The findings of this study show that having a technical background increases the likelihood for success. Other fields of study that may benefit a project are Business or Social Science. These were not as successful as Computer and Information Science, but should be favored over other fields when reviewing candidates for a requirements engineering position.

Those requirements engineers holding a certification were more successful. Certifications are issued by several professional organizations such as Project Management Institute (PMI), International Institute of Business Analysts (IIBA), and the American Society for Quality (ASQ). These certifications show a desire to continue to learn and grow. The certifications mandate that certificate holders gain continuing education credits each year. These certifications are based on standards which are considered the best practices within their respective fields. Holding a certification indicates an understanding of those best practices and how to apply them. A requirements engineer with a certification can bring those best practices and continuing education to a project so that the project can succeed.

It is helpful if the requirements engineer has training with facilitation and negotiation. Facilitation techniques may help organize meetings. They can also help the requirements engineer initiate or sustain a discussion. Negotiation skills can be helpful in two ways. First, negotiating skills may help users resolve conflicting requirements. Negotiation skills may also help to resolve disparities between what a project's stakeholders expect it to achieve and the resources that a project has to work with. When more resources are not forthcoming, negotiation skills can help a requirements engineer to determine which requirements will be removed from the scope. Negotiation skills can also help a requirements engineer to address problems with requirements that cannot be met with technologies to be used. The requirements engineer does not need experience applying these skills, but does need training on the basic techniques.

This work identified several techniques for gathering requirements that may increase the likelihood of success. Respondents identified Rapid Application Development/Rapid Prototyping software development as the most effective strategy for requirements gathering. These methodologies may increase the chances of success by helping users to visualize the intended system, similar to how an artist's rendering or model for a new structure brings a set of blueprints to life. It allows the user to have a better grasp of the final product and may help them to understand how it might function.

Scheduling or allocating at least 15% of the project time to gathering requirements doubled the chance of project success. Project success increased further when more than 15% was allocated to requirements. Some may find the requirements process should be simple or want to rush the process. The most critical decisions, however, are made while gathering requirements. The requirements dictate the work for the rest of the project. A greater investment of time in requirements will produce better requirements and a clearer direction for the project. This will also set clearer expectations for the project team, project sponsors and steering team members. The requirements engineer(s) judgment should be trusted with regard to how much time to allot for gathering requirements. If they have concerns and find the amount of time is inadequate, the project may be at risk for failure due to the increased risk of obtaining incomplete inaccurate requirements.

Following a standard for requirements increases project success. This can be a published standard such as IEEE or IIBA or this may be an organization's internally developed standard. A standard organizes the requirements, providing a familiar look or formatting to the content as well as a flow and continuity to the whole. A standard may also help the requirements engineer ensure all information in included for each requirement. For example, if each requirement section should have an associated use case, a standard format should make it easier to see if a use case is missing.

When gathering requirements, JAD Sessions, Use Cases, and Prototypes led to more successful projects. This finding underscores the claim that concrete examples improve success. As Rapid Prototyping increased success, using prototypes alone and not as part of the Rapid Prototyping methodology is also effective. It gives the user a clear view of the final product without having to build all its functionality. Joint Application Development (JAD) sessions bring together users, technical staff, and requirements engineers. Requirements engineers can facilitate the session helping users to share their requirements. The project team or technical staff can hear firsthand from the users what is needed. The project team may also gain a greater understanding of why a requirement is important and what need it fills. This can help in developing an appropriate solution. Use cases provide an understanding of how users will interact with features. Use cases provide some basic test steps and allow developers to understand how the feature must work because they have a clear description of how the feature will be used. All of these techniques provide ways to gain more detail for the requirements and make them as complete as possible. They also involve the user in decisions before any code is built and limit the decision a developer may have to make because of a lack of information in the requirements. This gives both users and project team members a clear understanding of what will be delivered in the final product.

Respondents stated that effective collaboration with clients is absolutely necessary to a project's success. Good interaction and communication with a project's clients—those who provide a project's requirements and determine its success—is essential for obtaining high quality requirements. In the absence of good communication, requirements cannot be discovered, a project's scope cannot be defined, and a suitable deliverable will probably not be developed. This highlights why projects need well-qualified requirements engineers. Skilled, experienced, and knowledgeable requirements engineers can establish good communications with their clients and help clients and project teams to collaborate well to a successful project end.

A final factor in increased project success is an effective collaboration between an experienced project manager and a qualified requirements engineer. If a project manager is a project's captain, then its requirements engineer is its navigator. There are experiences, skills, and knowledge that a requirements engineer must possess and continue to refine to drive the project to success. The requirements engineer can provide the project with the requirements or direction to keep the project on course.

Selecting the best person for the requirements engineer role should provide a higher quality of requirements for the project. Since all work is based on the requirements, this increases the likelihood for project success and lessens the chance for costly rework. These skills can be applied to any requirements engineering tasks, regardless of project methodology. Before design or development can begin, a clear understanding of the work is needed. Whether using a Waterfall, Spiral, or Agile method for a project, these skills can be applied to define the requirements for the work that is ready to commence. These skills will also allow the project team to meet customer expectations and communicate effectively with the customers. If the requirements engineer is not selected carefully, the requirements may be incomplete or incorrect. The team will not deliver an acceptable product because the final product was never clearly defined. This leads to customer dissatisfaction and ultimately project failure. Project failures mean strategic initiatives are never realized and organizations may not be able to grow and compete effectively, jeopardizing its future. With more attention to whom will serve as requirements engineer, more projects can succeed which will allow organizations to prosper.

Future Work

Extending this survey to a broader group of professionals could yield other useful correlations involving skills, experiences, requirements gathering, and project success. Also, a limited amount of project information was collected. While most respondents had worked on two or more projects during their careers, none of the responses provided information on more than one project. Another survey that could be left open for an extended period of time, potentially several years, to collect information about projects as they are completed might yield further insight into what qualities are present with requirements engineers on successful projects. Conversely, establishing projects, such that project members to work on requirements have the qualifications, skills, and experiences are found most in the more successful projects within this survey would provide further proof as to the impact these qualities have on a project's outcome.

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APPENDICES

Appendix A: Project Manager Survey

PM1. How many years have you been in the professional work force?
A. Less than 1 year
B. 1 to 5 years
C. 5 to 10 years
D. 10 to 20 years
E. 20+ years

PM2. How many years have you worked in Information Technology?
A. Less than 1 year
B. 1 to 5 years
C. 5 to 10 years
D. 10 to 20 years
E. 20+ years

PM3. How many years have you been in a project management role?
A. Less than 1 year
B. 1 to 5 years
C. 5 to 10 years
D. 10 to 20 years
E. 20+ years

PM4. How many total projects have you worked on in Information Technology?
A. 1-10
B. 11-25
C. 26-50
D. 51-100
E. 101-150
F. 150-200
G. More than 200

PM5. How many total projects have you managed in Information Technology?
A. 1-10
B. 11-25
C. 26-50
D. 51-100
E. 101-150
F. 150-200
G. More than 200

PM6. Which positions have you held during your career (select all that apply)?

A. Chief Executive Officer (CEO), Chief Information Officer (CIO), or other top level management position
B. Director of Project Management/Program Management Office
C. Educator/Trainer
D. Functional Manager/Resource Manager
E. Project Management Consultant
F. Project Manager
G. Program Manager
H. Project Management Specialist
I. Business Analyst / Requirements Analyst / Requirements Engineer
J. Software Architect
K. Software Engineer / Programmer
L. Database Administrator
M. Quality Assurance Analyst
N. Systems Administrator
O. Network Administrator
P. Other

PM7. What is the highest academic degree you have received?

A. High-School/Secondary Diploma
B. Some College or Associate's Degree
C. Bachelor's Degree
D. Master's Degree
E. Doctorate

PM8. What best describes your educational background (if you've studied more than one area, choose the field where you have spent the most time or effort)?

A. Art
B. Business
C. Computer/Information Science
D. Engineering
E. Mathematics
F. Health Sciences (such as Medicine, Nursing)
G. Natural Sciences (such as Biology, Chemistry, Physics)
H. Social Sciences (such as Sociology, Psychology, Political Science)
I. Other
J. No education/training in a specific area

PM9. Do you have a degree in Project Management?

A. Bachelor's Degree in Project Management
B. Master's Degree in Project Management
C. Doctorate in Project Management
D. No degree in Project Management

PM10. Do you hold any of the following certifications (choose all that apply)?

A. Certified Associate of Project Management - CAPM
B. Project Management Professional - PMP
C. Program Management Professional - PgMP
D. Scheduling Professional - PMI-SP
E. Risk Management Professional - PMI-RMP
F. OPM3 (any level)
G. IPMA (any level)
H. Prince2 (any level)
I. Certified Business Analysis Professional - CBAP
J. Certified Professional Facilitator – CPF
K. OMG Certified UML Professional – OCUP
L. Certified Software Quality Engineer – CSQE
M. None
N. Other (please specify)

Below are questions specific to individual projects. Please submit at least one set of questions. You may submit information for up to 10 projects – one set for each project you are considering as you respond:

PM11. How successful was this project in your opinion (scale of 1 to 10 with 10 being very successful)?

PM12. Did you have domain expertise when the project began?

A. Little or no domain expertise
B. Some domain expertise
C. Significant domain expertise
D. Expert in the domain when the project began

PM13. Was this project able to complete in the time scheduled?

A. Finished early
B. Finished on time
C. Finished 1-10% beyond the planned finish date
D. Finished 11- 25% beyond the planned finish date
E. Finished 26-50% beyond the planned finish date
F. Finished more than 50% beyond the planned finish date
G. Don't Know

PM14. Was the project complete within the planned amount of effort?

A. Finished using less effort
B. Finished using the planned level of effort
C. Finished using 1- 10% more effort than planned
D. Finished using 11- 25% more effort than planned
E. Finished using 26-50% more effort than planned
F. Finished using over 50% more effort than planned
G. Don't Know

PM15. Was this project able to complete within budget?

A. Finished under budget
B. Finished as budgeted
C. Finished 1-10% over budget
D. Finished 11-25% over budget
E. Finished 26-50% over budget
F. Finished more than 50% over budget
G. Don't Know

PM16. Was the scope of this project well defined?

A. Not defined
B. Somewhat defined
C. Well Defined
D. Very well defined
E. Don't Know

PM17. Was the scope of the project met?

A. Yes, all items were delivered as defined in the scope
B. No, fewer items were delivered than defined in the scope
C. No, more items were delivered than defined in the scope
D. Scope was not set for the project
E. Don't Know

PM18. Was there a plan in place to manage change requests?

A. No change management plan was put in place
B. A plan was in place, but not well documented
C. A well-documented plan was in place
D. Don't Know

PM19. How satisfied was the customer with the final deliverable (scale of 1 to 10 with 10 being very satisfied)?

PM20. Did the customer use or have plans to use/implement the final deliverable(s)?

A. Yes
B. No
C. Don't Know

PM21. Was the customer's organization or culture positively impacted by the final deliverable(s)? For example, would the final deliverable(s) help the customer to meet a strategic goal?

A. Yes
B. No
C. Don't Know

PM22. What software development methodologies were used on the project (select all that apply)?

A. Waterfall
B. Incremental/Phased Waterfall
C. Rapid Application Development/Rapid Prototyping
D. Spiral
E. Agile (including SCRUM, Crystal, DSDM, eXtreme Programming, Lean, etc.)
F. None
G. Don't Know
H. Other (please specify)

PM23. How was the project team assembled?

A. I was able to choose the team members.
B. I provided the skills needed and number or resources needed to a manager who then assigned team members to the project.
C. I specified how many resources were needed on the project, but did not specify any skills. A manager then assigned those resources to the project.
D. I asked that specific individuals be assigned to the project who I believed had the skills needed.
E. I had no input on team selection. I was assigned to the project and the team was already determined.

PM24. Who was tasked with gathering requirements for the project?

A. The end-user/customer provided requirements
B. Another part of the organization (such as marketing) provided requirements
C. A member of the software development team gathered requirements
D. Team members determined product functionality
E. We didn't gather requirements

PM25. What percent of the overall project time was devoted to gathering requirements?

PM26. Did any of those working on requirements have any of the following certifications (choose all that apply)?

A. Certified Associate of Project Management - CAPM
B. Project Management Professional - PMP
C. Program Management Professional - PgMP
D. Scheduling Professional - PMI-SP
E. Risk Management Professional - PMI-RMP
F. OPM3 (any level)
G. IPMA (any level)
H. Prince2 (any level)
I. Certified Business Analysis Professional - CBAP
J. Certified Professional Facilitator - CPF
K. Certified Software Quality Engineer – CSQE
L. Not aware of any certifications

PM27. What educational background did most people have who gathered requirements for this project?

A. Art
B. Business
C. Computer/Information Science
D. Engineering
E. Mathematics
F. Health Sciences (such as Medicine, Nursing)
G. Natural Sciences (such as Biology, Chemistry, Physics)
H. Social Sciences (such as Sociology, Psychology, Political Science)
I. Other
J. No education/training in a specific area
K. Do not know their educational background

PM28. Did any of those working on requirements have any education around tools and techniques of facilitation?

A. No training with facilitation
B. Little training with facilitation
C. Some training with facilitation
D. Much training with facilitation
E. Don't Know

PM29. Did any of those working on requirements have any education around tools and techniques of negotiation?

A. No training with negotiation
B. Little training with negotiation
C. Some training with negotiation
D. Much training with negotiation
E. Don't Know

PM30. Were any formal methods for gathering requirements followed on the project?

A. IIBA standards
B. IEEE standards
C. Organization has developed standards internally
D. No formal standard is used
E. Other standard (please specify)

PM31. Were any of the following techniques used to gather requirements on the project (select all that apply)?

A. Prototyping
B. JAD Sessions
C. Modeling – such as UML
D. Use Cases
E. Other (please specify)
F. None of these techniques

PM32. Briefly, what do you think was most beneficial to the success of the project (optional)?

PM33. Briefly, what do you think was most detrimental to the project (optional)?

Appendix B: Requirements Analyst, Business Analyst, or Requirements Engineer Survey

RE1. How many years have you been in the professional work force?
- A. Less than 1 year
- B. 1 to 5 years
- C. 5 to 10 years
- D. 10 to 20 years
- E. 20+ years

RE2. How many years have you worked in Information Technology?
- A. Less than 1 year
- B. 1 to 5 years
- C. 5 to 10 years
- D. 10 to 20 years
- E. 20+ years

RE3. How many years have you been in a requirements analyst role?
- A. Less than 1 year
- B. 1 to 5 years
- C. 5 to 10 years
- D. 10 to 20 years
- E. 20+ years

RE4. How many total projects have you worked on in Information Technology?
- A. 1-10
- B. 11-25
- C. 26-50
- D. 51-100
- E. 101-150
- F. 150-200
- G. More than 200

RE5. How many projects have you served in the requirements gathering role?
- A. 1-10
- B. 11-25
- C. 26-50
- D. 51-100
- E. 101-150
- F. 150-200
- G. More than 200

RE6. Which positions have you held during your career (select all that apply)?

A. Chief Executive Officer (CEO), Chief Information Officer (CIO), or other top level management position
B. Director of Project Management/Program Management Office
C. Educator/Trainer
D. Functional Manager/Resource Manager
E. Project Management Consultant
F. Project Manager
G. Program Manager
H. Project Management Specialist
I. Business Analyst / Requirements Engineer
J. Software Architect
K. Software Engineer / Programmer
L. Database Administrator
M. Quality Assurance Analyst
N. Systems Administrator
O. Network Administrator
P. Other

RE7. What is the highest academic degree you have received?

A. High-School/Secondary Diploma
B. Some College or Associate's Degree
C. Bachelor's Degree
D. Master's Degree
E. Doctorate

RE8. What best describes your educational background (if you've studied more than one area, choose the field where you have spent the most time or effort)?

A. Art
B. Business
C. Computer/Information Science
D. Engineering
E. Mathematics
F. Health Sciences (such as Medicine, Nursing)
G. Natural Sciences (such as Biology, Chemistry, Physics)
H. Social Sciences (such as Sociology, Psychology, Political Science)
I. Other
J. No education/training in a specific area

RE9. Do you hold any of the following certifications (choose all that apply)?

A. Certified Associate of Project Management - CAPM
B. Project Management Professional - PMP
C. Program Management Professional - PgMP
D. Scheduling Professional - PMI-SP
E. Risk Management Professional - PMI-RMP
F. OPM3 (any level)
G. IPMA (any level)
H. Prince2 (any level)
I. Certified Business Analysis Professional - CBAP
J. Certified Professional Facilitator – CPF
K. OMG Certified UML Professional – OCUP
L. Certified Software Quality Engineer – CSQE
M. None
N. Other (please specify)

RE10. Have you had any education around facilitation tools and techniques?

A. No training with facilitation
B. Little training with facilitation
C. Some training with facilitation
D. Much training with facilitation

RE11. Have you ever served as a facilitator in any situation?

A. Never served as facilitator
B. Infrequently serve as facilitator or assist with facilitation
C. Regularly serve as facilitator
D. Frequently serve as facilitator

RE12. Have you had any education around tools and techniques of negotiation?

A. No training with negotiation
B. Little training with negotiation
C. Some training with negotiation
D. Much training with negotiation

RE13. Have you ever served as a negotiator or mediator in any situation?

A. Never served as negotiator
B. Infrequently serve as negotiator or assist with negotiation
C. Regularly serve as negotiator
D. Frequently serve as negotiator

Below are questions specific to individual projects. Please submit at least one set of questions. You may submit information for up to 10 projects – one set for each project you are considering as you respond:

RE14. How successful was this project in your opinion (scale of 1 to 10 with 10 being very successful)?

RE15. Did you have domain expertise when the project began?

A. Little or no domain expertise
B. Some domain expertise
C. Significant domain expertise
D. Expert in the domain when the project began

RE16. Was this project able to complete in the time scheduled?

A. Finished early
B. Finished on time
C. Finished 1-10% beyond the planned finish date
D. Finished 11- 25% beyond the planned finish date
E. Finished 26-50% beyond the planned finish date
F. Finished more than 50% beyond the planned finish date
G. Don't Know

RE17. Was the project complete within the planned amount of effort?

A. Finished using less effort
B. Finished using the planned level of effort
C. Finished using 1- 10% more effort than planned
D. Finished using 11- 25% more effort than planned
E. Finished using 26-50% more effort than planned
F. Finished using over 50% more effort than planned
G. Don't Know

RE18. Was this project able to complete within budget?

A. Finished under budget
B. Finished as budgeted
C. Finished 1-10% over budget
D. Finished 11-25% over budget
E. Finished 26-50% over budget
F. Finished more than 50% over budget
G. Don't Know

RE19. Was the scope of this project well-defined?

A. Not defined
B. Somewhat defined
C. Well Defined
D. Very well defined
E. Don't Know

RE20. Was the scope of the project met?

A. Yes, all items were delivered as defined in the scope
B. No, fewer items were delivered than defined in the scope
C. No, more items were delivered than defined in the scope
D. Scope was not set for the project
E. Don't Know

RE21. Was there a plan in place to manage change requests?

A. No change management plan was put in place
B. A plan was in place, but not well documented
C. A well-documented plan was in place
D. Don't Know

RE22. How satisfied was the customer with the final deliverable (scale of 1 to 10 with 10 being very satisfied)?

RE23. Did the customer use or have plans to use the final deliverable(s)?

A. Yes
B. No
C. Don't Know

RE24. Was the customer's organization or culture positively impacted by the final deliverable(s)? For example, would the final deliverable(s) help the customer to meet a strategic goal?

A. Yes
B. No
C. Don't Know

RE25. What software development methodology was used on the project (select all that apply)?

A. Waterfall
B. Incremental/Phased Waterfall
C. Rapid Application Development/Rapid Prototyping
D. Spiral
E. Agile (including SCRUM, Crystal, DSDM, eXtreme Programming, Lean, etc.)
F. None
G. Don't Know
H. Other (please specify)

RE26. Who was tasked with gathering requirements for the project?

A. The end-user/customer provided requirements
B. Another part of the organization (such as marketing) provided requirements
C. A member of the software development team gathered requirements
D. Team members determined product functionality
E. We didn't gather requirements

RE27. What percent of the overall project time was devoted to gathering requirements?

RE28. How adequate was the amount of time planned for requirements gathering on the project?

A. Very Adequate
B. Adequate
C. Somewhat Adequate
D. Inadequate
E. There was no plan/schedule around requirements.

RE29. Were any formal methods for gathering requirements followed on the project?

A. IIBA standards
B. IEEE standards
C. Organization has developed standards internally
D. No formal standard is used
E. Other standard (please specify)

RE30. Were any of the following techniques used to gather requirements on the project (select all that apply)?

A. Prototyping
B. JAD Sessions
C. Modeling – such as UML
D. Use Cases
E. Other (please specify)
F. None of these techniques

RE31. Briefly, what do you think was most beneficial to the success of the project (optional)?

RE32. Briefly, what do you think was most detrimental to the project (optional)?

Appendix C: Additional Analysis of Experiences, Skills, and Qualifications

PM4 / RE4: How many total projects have you worked on in Information Technology?

Respondents were asked how many projects they have worked on in their careers. The respondent may have served on these projects in any role. The greatest number of respondents had worked on 1-10 projects. The median was 26-50 projects among respondents. Table 57 provides the median and standard deviation.

Table 57 Median and Standard Deviation of Total Number of Projects Worked by Respondents

Median	3.00 (26-50 projects)
Std. Deviation	1.961

Reviewing the responses shows that each group is represented and that most of the responses are evenly distributed. There are much fewer that had worked on 101-150 or 150 to 200 projects. Table 58 shows the number of projects worked.

Table 58 Total Number of Projects Worked

Projects Worked	Frequency	Percent
1-10	23	21.7
11-25	18	17.0
26-50	21	19.8
51-100	20	18.9
101-150	7	6.6
150-200	2	1.9
More than 200	15	14.2
Total	106	100.0

Considering projects with a success rating of 8, 9, or 10, there is no trend of more projects worked translating into greater project success. The most successful categories were those with more than 200 projects, 51-100 projects, and 101 – 150 projects. Those who worked on 200 or more projects reported 6 successful projects for each failed project. Those that worked on 51-100 projects reported 5.3 successful projects for every failed project. These are the greatest ratios in the data set. Table 59 shows number of Information Technology projects worked compared to project success.

Table 59 Project Success Compared to Number of Projects Worked

		Project success or failure				Total
		Successful	% Success	Failure	% Failure	
How many total projects have you worked on in Information Technology?	1-10	12	75	4	25	16
	11-25	7	58.3	5	41.7	12
	26-50	15	75	5	25	20
	51-100	16	84.2	3	15.8	19
	101-150	5	83.3	1	16.7	6
	150-200	1	50	1	50	2
	More than 200	12	85.7	2	14.3	14
Total		68	76.4	21	23.6	89

Figure 31 further illustrates there are particular trends between the number of projects worked and project success. The most successful categories were 1-10, 26-25, 51-100, 101-150, and more than 200 projects. Each of these categories has a project failure to success ratio of 3, 3, 5.3, 5, and 6. This shows that there is an increase in project success as an individual works on more projects. There also seems to be a significant increase in success having worked on more than 26 projects.

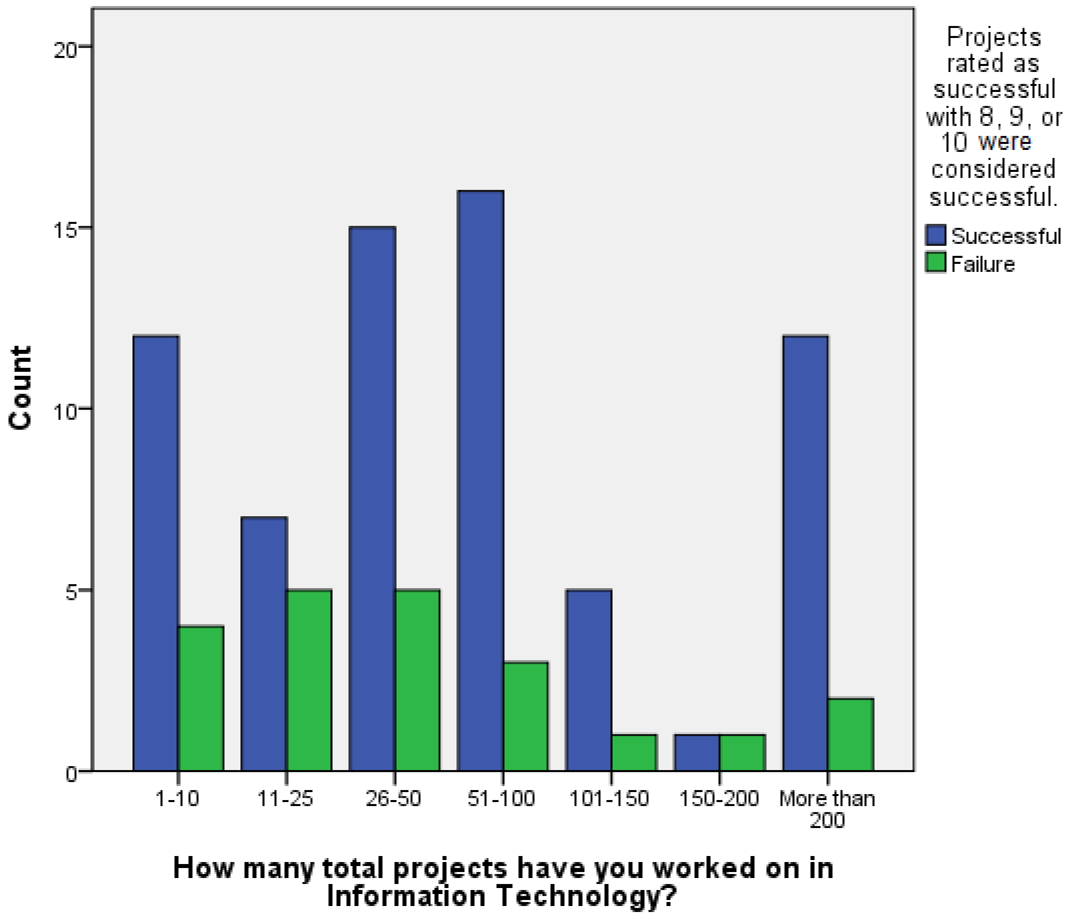

Figure 31 Project Success Compared to Number of Projects Worked

Analyzing the responses to determine statistical significance shows the null hypothesis cannot be rejected. To reject the null hypothesis with 95% confidence, the χ^2 value would have to be 12.592. The χ^2 value for these data is 4.462 which is much less than 12.592. The p-value for this data is 0.614 which is inconclusive or that it cannot be determined that the number of IT projects an individual has worked on has any impact on project success. Table 60 shows the results of the chi-square analysis.

Table 60 Test of Null Hypothesis Comparing Project Success to Number of Projects Worked

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.462[a]	6	.614
Likelihood Ratio	4.229	6	.646
Linear-by-Linear Association	1.204	1	.273
N of Valid Cases	89		

a. 9 cells (64.3%) have expected count less than 5. The minimum expected count is .47.

Project managers Reviewing the responses just from project managers does not reveal any trend in their responses. Those having worked on 11-15 projects reported the least success with projects. Those who had worked 150 – 200 projects reported the greatest success. Table 61 shows the project managers responses.

Table 61 Project Success Compared to Number of Projects Worked by Project Managers

		Project success or failure				Total
		Successful	% Success	Failure	% Failure	
How many total projects have you worked on in Information Technology?	1-10	8	80	2	20	10
	11-25	1	50	1	50	2
	26-50	8	88.8	1	22.2	9
	51-100	10	83.3	2	16.7	12
	101-150	5	83.3	1	16.7	6
	150-200	1	100	0	0	1
	More than 200	8	88.8	1	22.2	9
Total		41	83.7	8	16.3	49

Figure 32 further illustrates a lack of any trend. However, projects with a success rating of 9 or 10 consisted predominantly of those who had worked 51-100 projects.

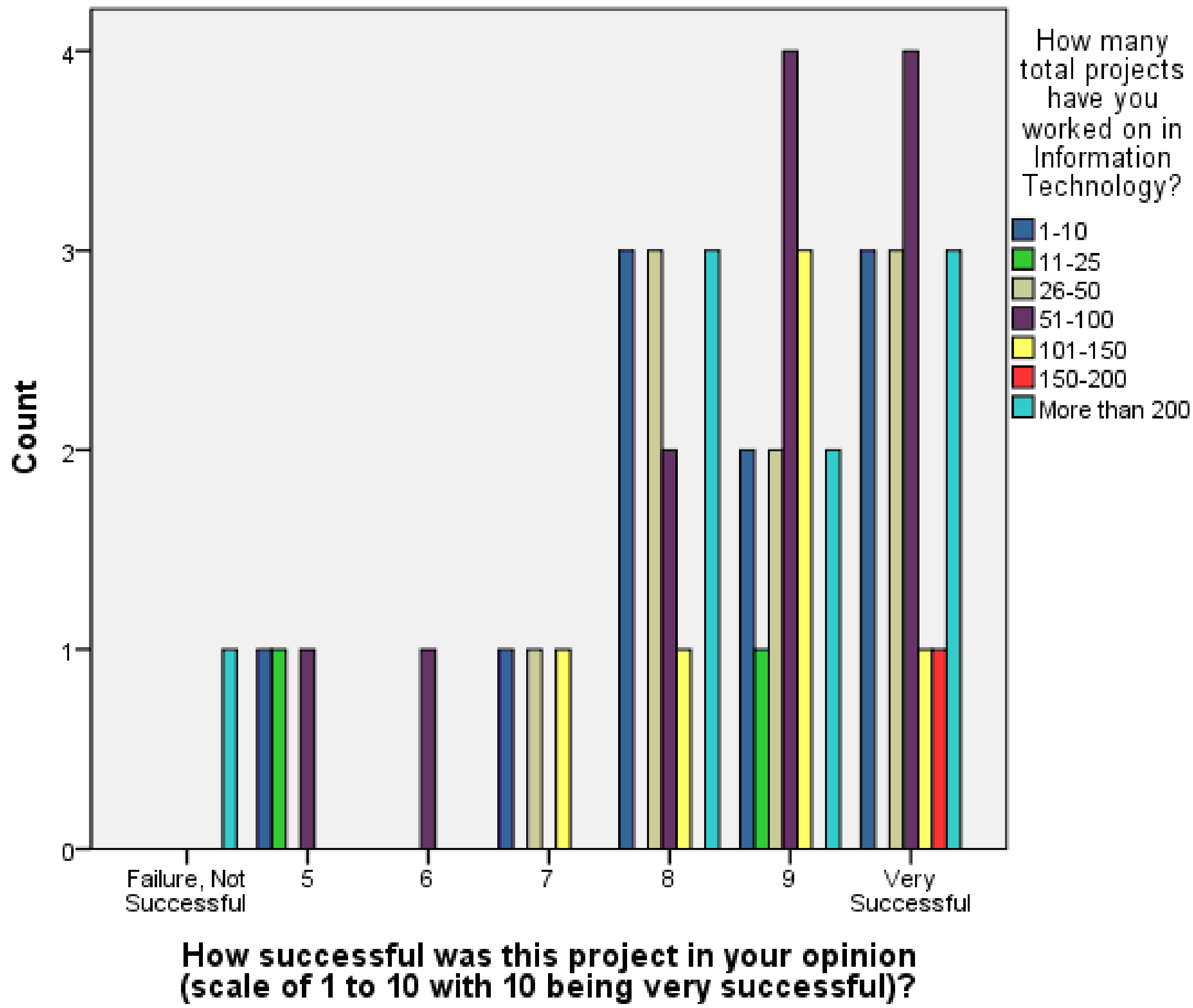

Figure 32 Project Success Compared to Number of Projects Worked by Project Managers

<u>Requirements engineers</u> Requirements engineers had the best success rates with 51-100 projects worked. Those having worked more than 200 projects had the next highest success rates. Table 62 shows the requirements engineers responses.

Table 62 Project Success Compared to Number of Projects Worked by Requirements Engineers

		Project success or failure				
		Successful	% Success	Failure	% Failure	Total
How many total projects have you worked on in Information Technology?	1-10	4	66.7	2	33.3	6
	11-25	6	60	4	40	10
	26-50	7	63.6	4	36.4	11
	51-100	6	85.7	1	14.3	7
	101-150	0	0	0	0	0
	150-200	0	0	1	100	1
	More than 200	4	80	1	20	5
Total		27	67.5	13	32.5	40

Figure 33 shows that they are mostly evenly distributed, especially for the very successful projects (those rated as 10). There was a higher number of projects rated as an 8 that had a requirements engineer who had worked on 26-50 projects. Projects rated as a 9 had a high number of requirements engineers who had worked on 51-100 projects. This suggests that it might increase the probability for success for the requirements engineer to have worked on at least 25 projects in the past.

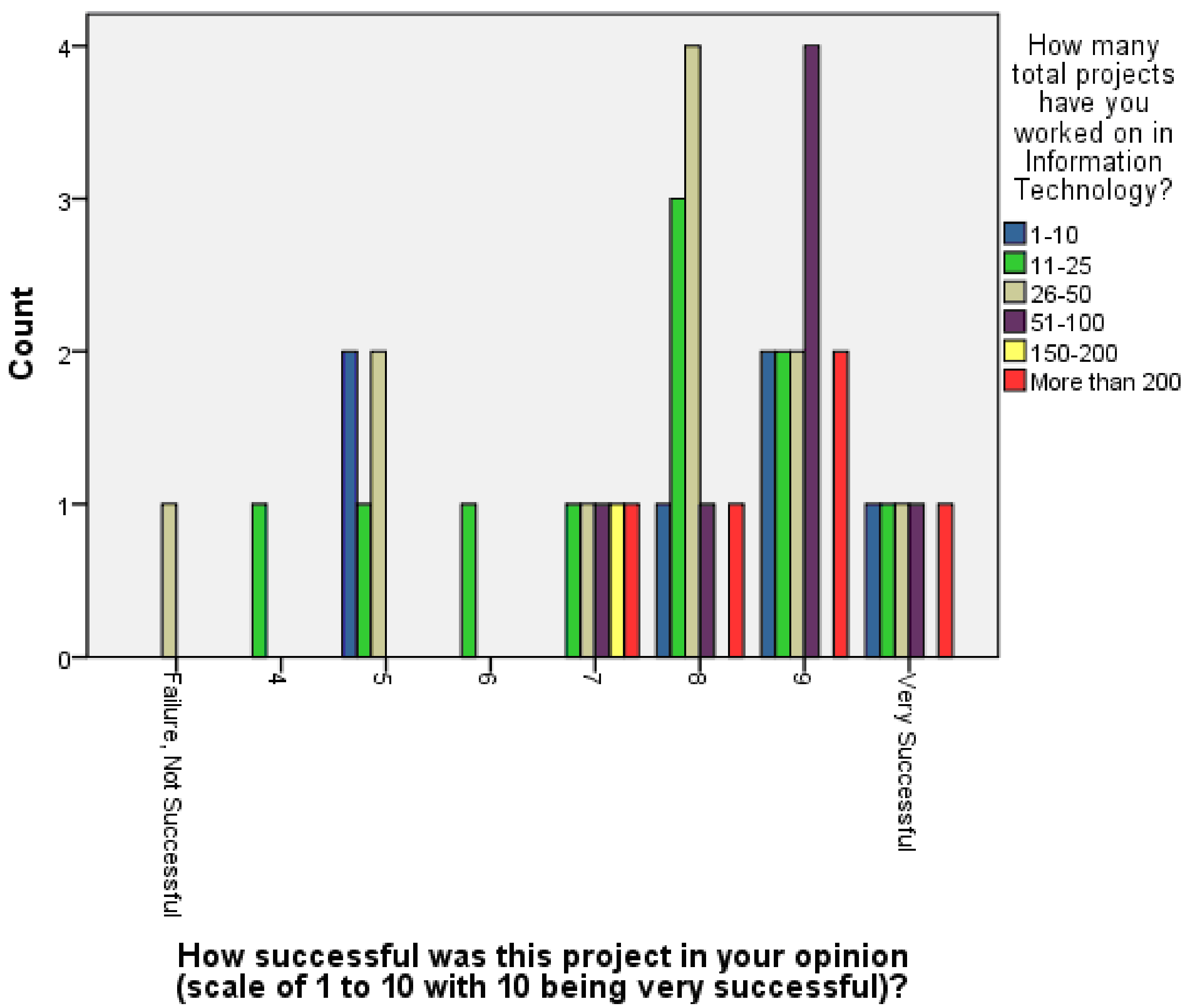

Figure 33 Project Success Compared to Number of Projects Worked by Requirements Engineers

Summary It may be beneficial to have requirements engineers and project managers who have worked on at least 25 projects in the past. However, the null hypothesis cannot be rejected with these data.

PM5: How many total projects have you managed in Information Technology?

Project managers were not only asked how many projects they worked on, but also how many of those projects they managed. This was to determine if perhaps managing more projects would increase project success. However, the greatest numbers of responses on the most successful projects were those who had managed 26-50 projects. Table 63 shows the number of projects managed compared to project success.

Table 63 Project Success Compared to Number of Projects the Project Managers Managed

		Project success or failure.				
		Successful	% Success	Failure	% Failure	Total
How many total projects have you managed in Information Technology?	1-10	10	71.4	4	28.6	14
	11-25	6	100	0	0	6
	26-50	11	73.3	4	26.7	15
	51-100	6	100	0	0	6
	101-150	4	100	0	0	4
	150-200	2	100	0	0	2
	More than 200	2	100	0	0	2
Total		41	83.7	8	16.7	49

Figure 34 shows that the greatest number of successful projects was reported by those who had managed 26-50 projects. Those who managed 11-25 or more than 50 projects did report any failures. This indicated that having managed at least 10 projects in the past might increase success.

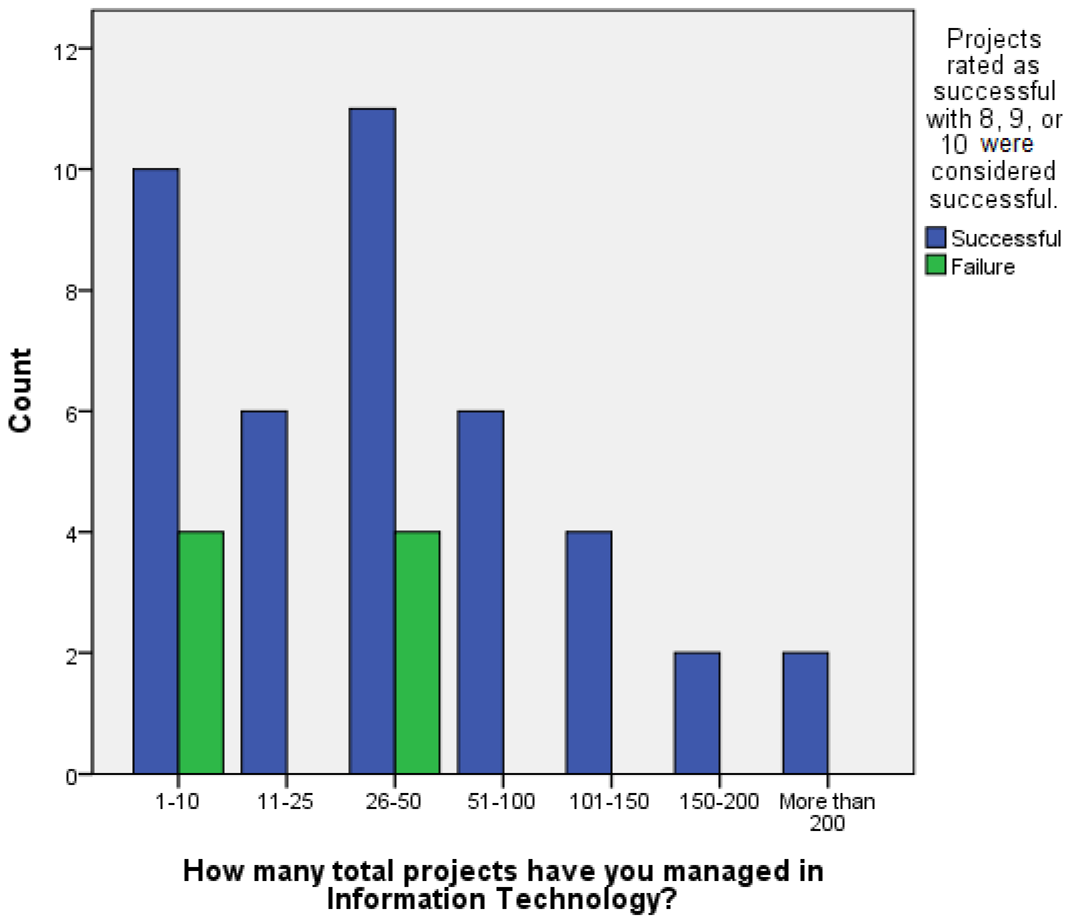

Figure 34 Project Success Compared to Number of Projects the Project Managers Managed

The number of projects managed by project managers was analyzed for statistical significance. A 95% confidence level would require a χ^2 value of 12.592. The χ^2 value for these data is 6.613. The null hypothesis cannot be rejected. The p-value is 0.358 which is inconclusive. Data were grouped several ways to try to find a conclusive correlation, but no trends were found. Therefore, the number of projects managed by the Project Manger does not necessarily impact project success. Table 64 provides the results of the chi-square analysis.

Table 64 Test of Null Hypothesis Comparing Project Success to Number of Projects Managed by Project Managers

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.613[a]	6	.358
Likelihood Ratio	9.465	6	.149
Linear-by-Linear Association	2.652	1	.103
N of Valid Cases	49		

a. 10 cells (71.4%) have expected count less than 5. The minimum expected count is .33.

<u>Summary</u> It may increase the probability for project success if the project manager has managed at least 10 projects in the past. However, the null hypothesis cannot be rejected. Statistically, the number of projects managed does not directly impact project success

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<u>RE5: How many projects have you served in the requirements gathering role?</u>

Requirements engineers were also asked how many projects they had served in the requirements engineer role. Similarly to the project managers, this was to discover if serving as requirements engineer more frequently impacted project success. There does seem to be a trend of increasing success with more projects served in the requirements engineer role. Table 65 shows the responses compared to project success.

Table 65 Project Success vs. Number of Projects Where Requirements Engineers Served in Requirements Gathering Role

		Project success or failure				
		Successful	% Successful	Failure	% Failure	Total
How many projects have you served in the requirements gathering role?	1-10	7	58.3	5	41.7	12
	11-25	7	58.3	5	41.7	12
	26-50	5	83.3	1	16.7	6
	51-100	6	75	2	25	8
	101-150	1	100	0	0	1
	More than 200	1	100	0	0	1
Total		27	67.5	13	32.5	40

Figure 35 illustrates that the number of failures decreases the greater the number of projects worked. Those who worked 1-10 and 11-25 projects in the requirements gathering role reported the greatest number of successes. However, those who worked on 101-150 or more than 200 projects in the requirements gathering role reported they had no failures and 100% success. Those who worked as requirements engineer in 26-50 projects had the greatest success to failure ratio; for every project that failed, 5 succeeded.

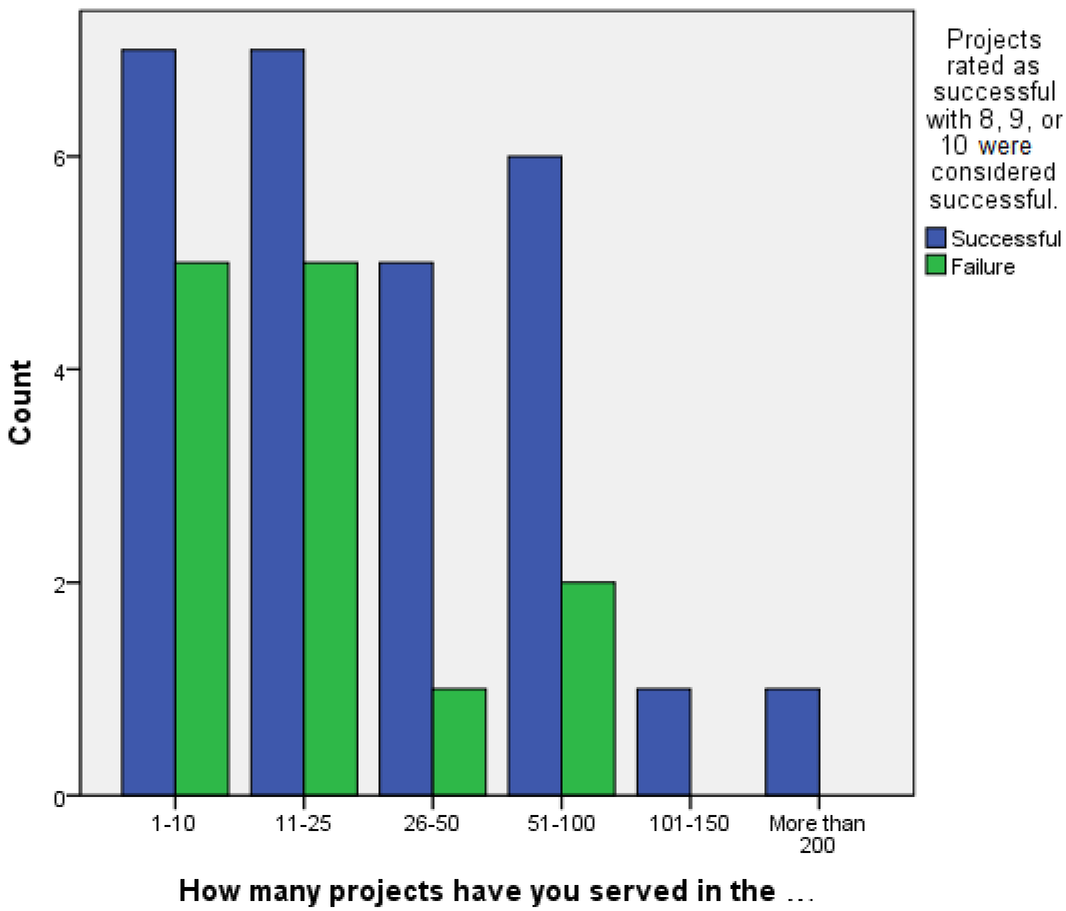

Figure 35 Project Success vs. Number of Projects Where Requirements Engineers Served in Requirements Gathering Role

Analyzing the data for statistical significance shows that the null hypothesis cannot be rejected. A χ^2 value of 11.070 would be needed to reject the null hypothesis with 95% confidence. The χ^2 value with these data is 2.773. Additionally, the p-value for this data is 0.735 which is inconclusive. Therefore, the number of projects served as a requirements analyst does not necessarily impact project success. Table 66 provides the results of the chi-square analysis.

Table 66 Test of Null Hypothesis Comparing Project Success to Number of Projects Requirements Engineers Served in the Requirements Gathering Role

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.773[a]	5	.735
Likelihood Ratio	3.441	5	.632
Linear-by-Linear Association	2.004	1	.157
N of Valid Cases	40		

a. 9 cells (75.0%) have expected count less than 5. The minimum expected count is .33.

Summary In the data, there seems to be a trend that serving as the requirements engineer for more than 25 projects increases project success. However, the number of projects served as a requirements engineering does not statistically impact project success

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PM9: Do you have a degree in Project Management?

Project managers were also asked if they held a degree in Project Management. Of respondents, 93.9% did not have a degree in project management. Very few reported having a project management degree and so it cannot be determined if having a project management degree has any impact on project success. Table 67 shows the responses compared to project success.

Table 67 Project Success Compared to Whether or Not the Project Manager Has a Degree in Project Management

		Project success or failure				Total
		Successful	% Success	Failure	% Failure	
Do you have a degree in Project Management?	Bachelor's Degree in Project Management	1	100	0	0	1
	Master's Degree in Project Management	1	50	1	50	2
	No degree in Project Management	39	84.8	7	15.2	46
Total		41	83.7	8	16.3	49

Figure 36 shows that those who did have project management degrees were not necessarily more successful, but there is too little data to analyze for any relationships.

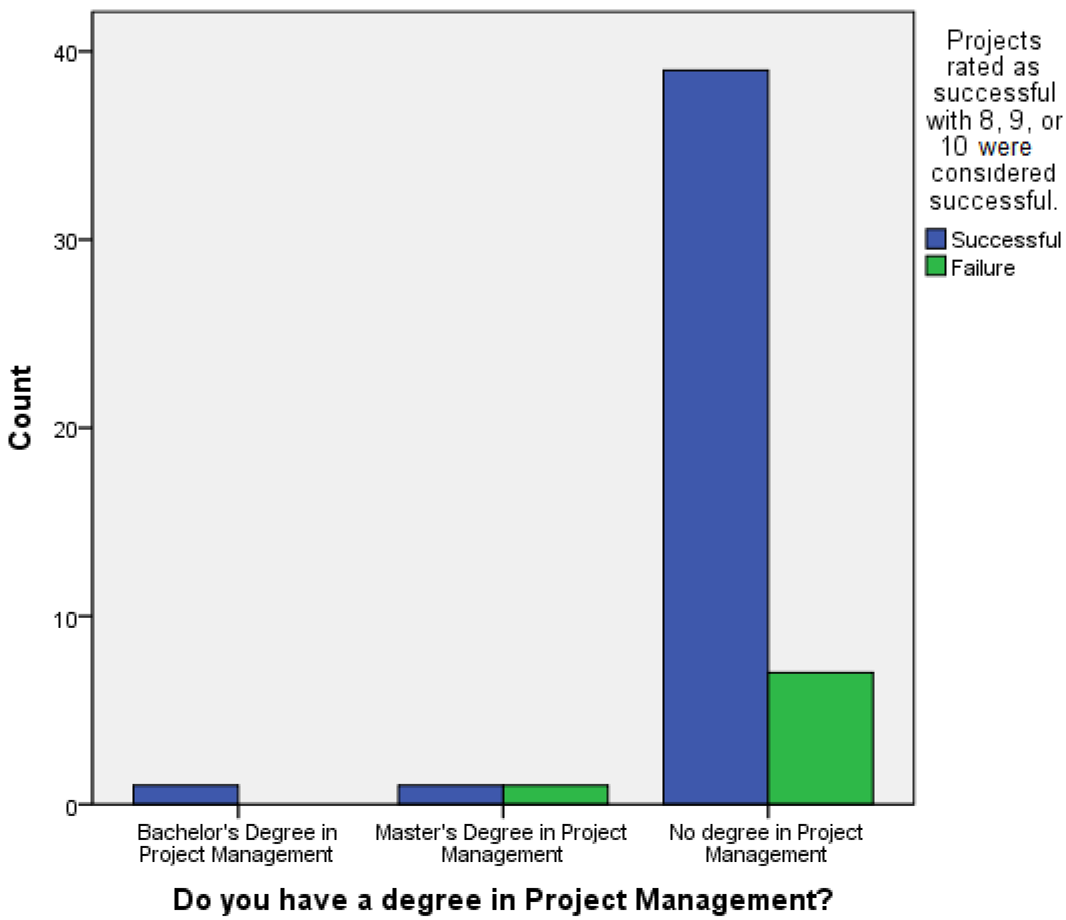

Figure 36 Project Success Compared to Whether or Not the Project Managers Has a Degree in Project Management

Testing the null hypothesis shows that the data are not statistically significant. This is expected given the responses. A χ^2 value of 5.991 would be needed to reject the null hypothesis with 95% confidence. For this data, the χ^2 value is 1.897. The p-value is 0.387 which is inconclusive. It cannot be determined if a project management degree has any impact on the success of the project. Table 68 provides the results of the chi-square analysis.

Table 68 Test of Null Hypothesis Comparing Project Success to Whether or Not the Project Manager Has a Degree in Project Management

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.897[a]	2	.387
Likelihood Ratio	1.607	2	.448
Linear-by-Linear Association	.329	1	.566
N of Valid Cases	49		

a. 4 cells (66.7%) have expected count less than 5. The minimum expected count is .16.

<u>Summary</u> It cannot be determined if a Project Management degree has any impact on the success of a project. Not enough data were provided to determine this correlation.

<u>PM23: How was the project team assembled?</u>

The question was only posed to project managers. This is because project managers are usually responsible for assembling and/or managing a team. The requirements engineer does not provide this service. Among project managers, 51% indicated they did not have any input as to who was assigned to the project team. However, 84% of these projects succeeded. The most successful was when the Project Manger asked for specific individuals to be assigned to the project. Of projects where specific individuals were requested, 87.5% succeeded. It may improve project success slightly if the project manager is able to choose team member, but project managers seem to be able to work with the resources they are given to complete a project. Table 69 shows the responses compared to project success.

Table 69 Project Success Compared to Methods for Assembling Teams

		Project success or failure				
		Successful	% Successful	Failure	% Failure	Total
How was the project team assembled ?	I was able to choose the team members.	6	85.7	1	14.3	7
	I provided the skills needed and number of resources needed to a manager who then assigned team members to the project.	5	71.4	2	28.6	7
	I specified how many resources were needed on the project, but did not specify any skills.	2	100	0	0	2
	I asked that specific individuals be assigned to the project who I believed had the skills needed.	7	87.5	1	12.5	8
	I had no input on team selection. I was assigned to the project and the team was already determined.	21	84	4	16	25
Total		41	83.7	8	16.3	49

Figure 37 shows that most of successful projects are situations where the Project Manger did not have any input on team selection.

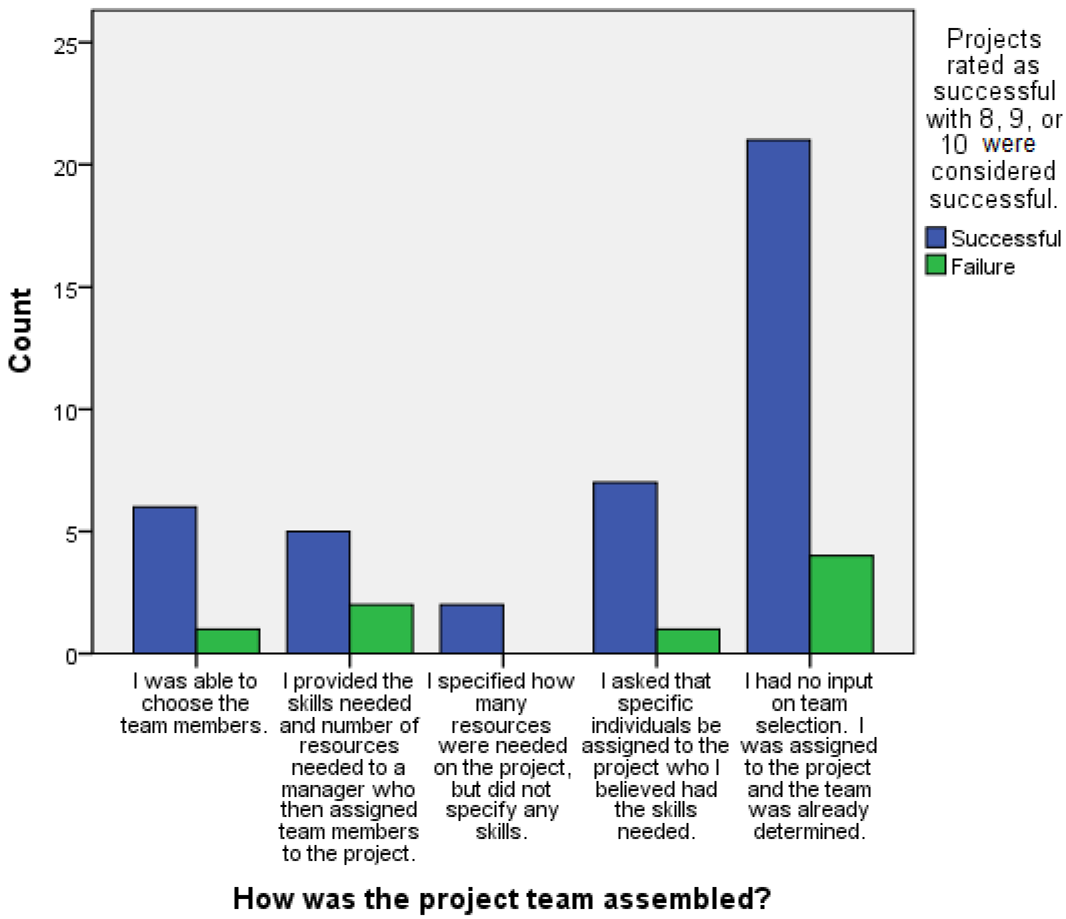

Figure 37 Project Success Compared to Methods for Assembling Teams

A test of the statistical significance shows that team selection is not statistically significant to impact project success. A χ^2 value of 9.488 would be needed to reject the null hypothesis with 95% confidence. The data yielded a χ^2 value of 1.268. The p-value was 0.867 which is inconclusive. The null hypothesis is retained. Table 70 shows the results of the chi-square analysis.

Table 70 Test of Null Hypothesis Comparing Project Success to Methods of Assembling Teams

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.268[a]	4	.867
Likelihood Ratio	1.485	4	.829
Linear-by-Linear Association	.068	1	.795
N of Valid Cases	49		

a. 6 cells (60.0%) have expected count less than 5. The minimum expected count is .33.

Summary There was a slight increase in project success when the project manager was able to choose team members. However, projects were still very successful when the Project Manger had no input into the team makeup. Also, the null hypothesis is not rejected and therefore the manner in which the team is assembled does not directly impact project success.

<u>PM24 / RE26: Who was tasked with gathering requirements for the project?</u>

Respondents were asked who gathered requirements for their project. This was to determine if any particular situation led to a more successful project. Of responses, 31.4% indicated the end-user or customer provided the requirements, 30.3% of responses indicated the project team determined the requirements, and 25.8% of responses indicated a member of the software development team gathered requirements. Of projects where team members determined the functionality, 81.4% were successful. Of projects where the end-user or customer provided requirements, 78.6% succeeded. Of projects where a member of the software development team gathered requirements, 69.6% succeeded. There may be a slight increase for success when the team members determine the requirements, but there is not a great distinction between any of the situations. Table 71 provides the responses.

Table 71 Project Success Compared to the Person or Group Tasked With Gathering Requirements

		Project success or failure				
		Successful	% Successful	Failure	% Failure	Total
Who was tasked with gathering requirements for the project?	The end-user/customer provides requirements.	22	78.6	6	21.4	28
	Another part of the organization (such as marketing) provides requirements.	8	72.7	3	27.3	11
	A member of the software development team gathers requirements.	16	69.6	7	30.4	23
	Team members determine product functionality	22	81.5	5	18.5	27
Total		68	76.4	21	23.6	89

Figure 38 shows that both end-user/customer providing requirements and team members determining requirements occurred most in more successful projects.

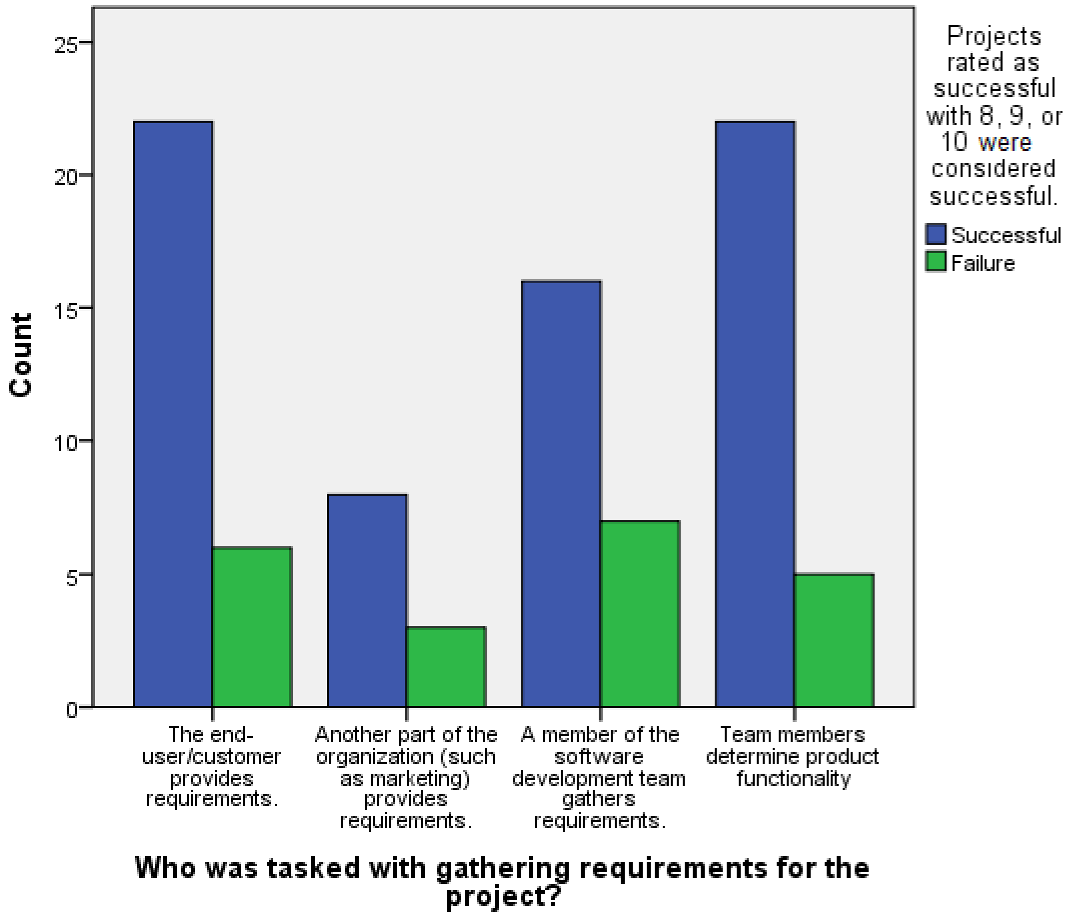

Figure 38 Project Success Compared to the Person or Group Tasked With Gathering Requirements

A test of the null hypothesis shows that this is not statistically significant. A χ^2 value of 7.815 would be needed to be able to reject the null hypothesis with 95% cofidence. The χ^2 value with these data is 1.138 and below the 7.815 needed to reject the null hypothesis. The p-value is 0.768 which is inconclusive. The person or people providing requirements does not determine project success. Table 72 provides the results of the chi-square analysis.

Table 72 Test of Null Hypothesis of Project Success Compared to the Person or Group Tasked With Gathering Requirements

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.138[a]	3	.768
Likelihood Ratio	1.125	3	.771
Linear-by-Linear Association	.013	1	.909
N of Valid Cases	89		

a. 1 cells (12.5%) have expected count less than 5. The minimum expected count is 2.60.

Project managers Among project managers, 30.6% of projects had the end-user or customer providing requirements. Another 30.6% had the team members determine product functionality. For 22.4% of projects, a member of the software development team gathered requirements. For 16.3%, another part of the organization provided requirements. Of these, the team members determining project functionality was successful in 93.3% of projects. Table 73 shows the project managers responses.

Table 73 Project Success Compared to Person or Groups Tasked With Gathering Requirements According to Project Managers

		Project success or failure				
		Successful	% Successful	Failure	% Failure	Total
Who was tasked with gathering requirements for the project?	The end-user/customer provides requirements.	12	80	3	20	15
	Another part of the organization (such as marketing) provides requirements.	6	75	2	25	8
	A member of the software development team gathers requirements.	9	81.8	2	18.2	11
	Team members determine product functionality	14	93.3	1	6.7	15
Total		41	83.7	8	16.3	49

Figure 39 shows the team members determining product functionality occurs most frequently in more successful projects. However, with the most successful projects, the most predominant situation was that a member of the software development team gathered requirements.

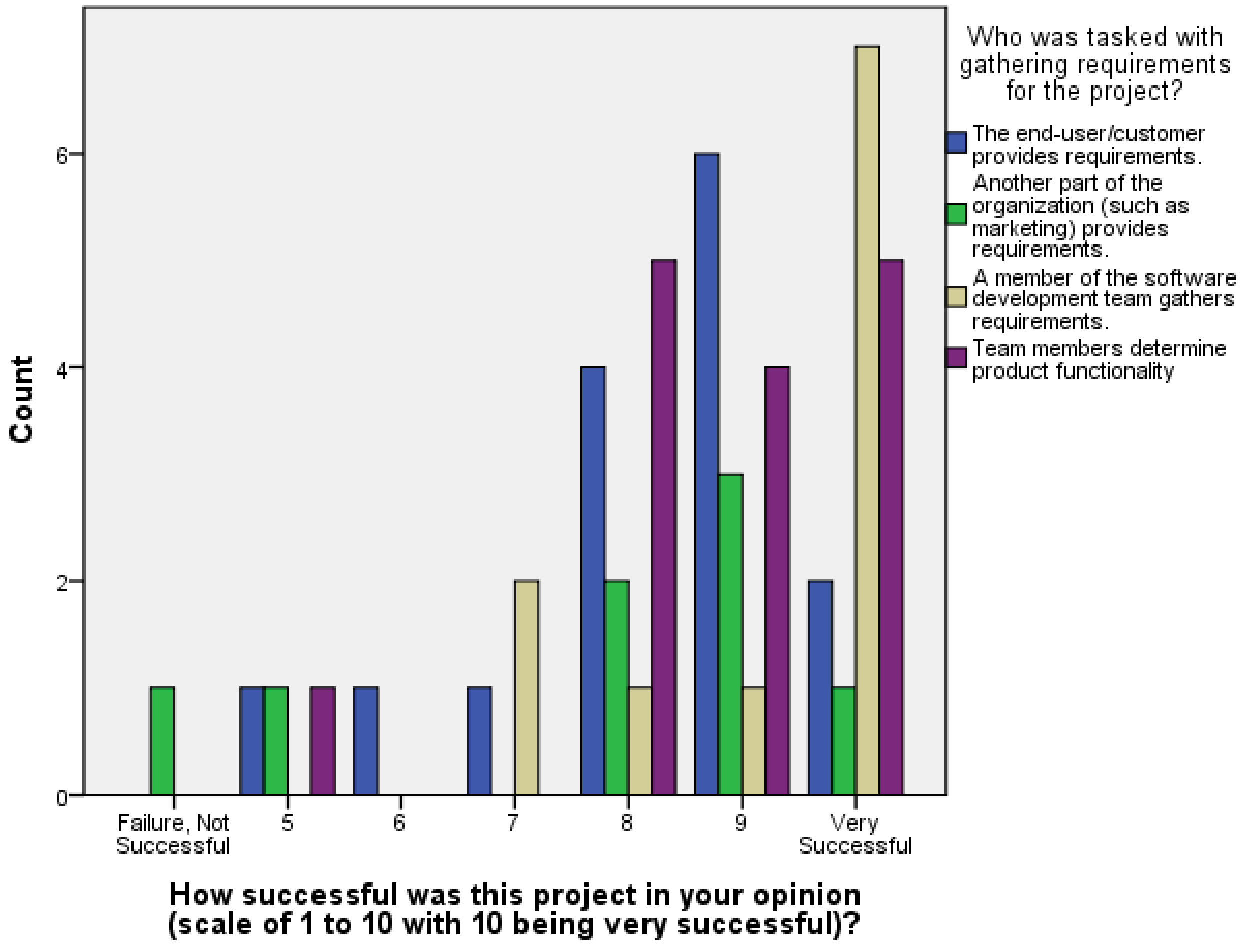

Figure 39 Project Success Compared to Person or Groups Tasked With Gathering Requirements According to Project Managers

<u>Requirements engineers</u> Requirements engineers identified much the same people gathering requirements. The end-user/customer provided requirements for 32.5% of projects. Members of the software team gathering requirements and team members determining product functionality accounted for 30% each.

Of projects where end-users or customers providing requirements, 76.9% succeeded. Of projects with team members determining product functionality, 66.7% succeeded. Of projects where a member of the software development team gathers requirements, 58.3% succeeded. The overall set of data indicated that team members determining requirements was most successful. Among requirements engineers, end-users or customers providing requirements was most successful. Table 74 provides the requirements engineers responses.

Table 74 Project Success vs. Person or Groups Tasked With Gathering Requirements According to Requirements Engineers

		Project success or failure				
		Successful	% Successful	Failure	% Failure	Total
Who was tasked with gathering requirements for the project?	The end-user/customer provides requirements.	10	76.9	3	23.1	13
	Another part of the organization (such as marketing) provides requirements.	2	66.7	1	33.3	3
	A member of the software development team gathers requirements.	7	58.3	5	41.7	12
	Team members determine product functionality	8	66.7	4	33.3	12
Total		27	67.5	13	32.5	40

Figure 40 shows how the end-user or customer providing requirements occurred most in the most successful projects (rated 8, 9, or 10). For the top success ratings, a member of the software team gathering requirements and team members determining functionality were more frequent.

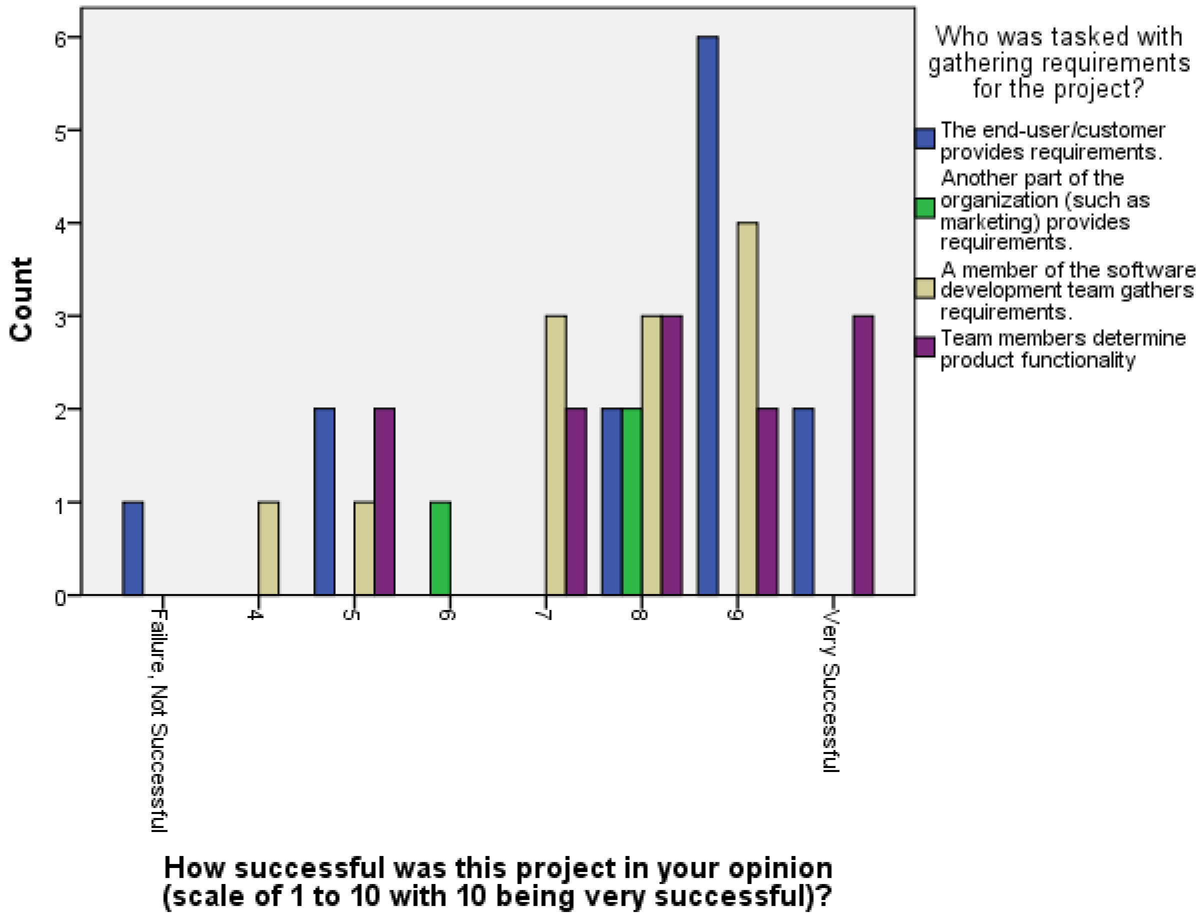

Figure 40 Project Success Compared to Person or Groups Tasked With Gathering Requirements According to Requirements Engineers

<u>Summary</u> Having team members determine functionality was the most successful situation in the data. Project managers alone also indicated that team members determining functionality was most successful. However, with requirements engineers, the end-user providing requirements was most successful. The null hypothesis could not be rejected and therefore the person or persons working on requirements does not directly affect project success.

PM28: Did any of those working on requirements have any education around tools and techniques of facilitation?

For these data, project managers were asked their understanding of facilitation education/training levels of their project team members assigned to requirements analysis tasks. Of the responses, 34.7% indicated there was some training, 24.5% had little training with facilitation, and 18.4% had no training with facilitation. For 16.3%, project managers were unaware of any facilitation training, while 6.1% had much training with facilitation. Of those projects where team members had much training on facilitation, 100% succeeded. Of those with some facilitation training, 88.2% of their projects succeeded. Of those with little training with facilitation, 83.3% of the projects succeeded. For those with no facilitation training, 77.8% of the projects succeeded. This indicates that facilitation training can increase the likelihood of project success. Table 75 shows the responses compared to project success.

Table 75 Project Success Compared to Facilitation Training of Team Members Working on Requirements According to Project Managers

		Project success or failure				
		Successful	% Successful	Failure	% Failure	Total
Did any of those working on requirements have any education/training around tools and techniques of facilitation?	No training with facilitation	7	77.8	2	22.2	9
	Little training with facilitation	10	83.3	2	16.7	12
	Some training with facilitation	15	88.2	2	11.8	17
	Much training with facilitation	3	100	0	0	3
	Don't Know	6	75	2	25	8
Total		41	83.7	8	16.3	49

Figure 41 shows that those categories with greater facilitation training occur more frequently in more successful projects.

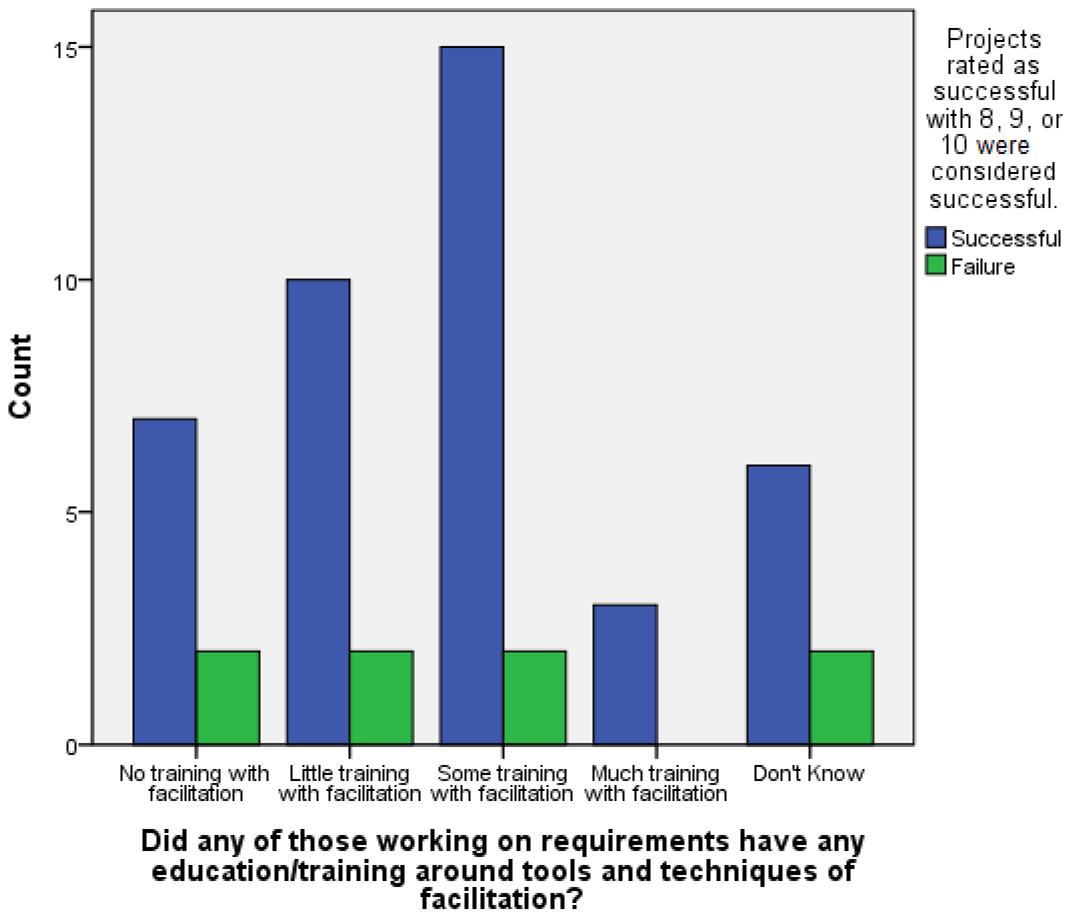

Figure 41 Project Success Compared to Facilitation Training of Team Members Working on Requirements According to Project Managers

The data were analyzed for to determine statistical significance. The null hypothesis cannot be rejected. A χ^2 value of 9.488 would be needed to reject the null hypothesis with 95% confidence. The χ^2 value for the data is 1.515 and below the 9.488 needed. The p-value is 0.824 which is inconclusive. Therefore, the amount of facilitation training does not impact project success. Table 76 provides the results of the chi-square analysis.

Table 76 Test Null Hypothesis of Project Success Compared to Facilitation Training of Team Members Working on Requirements According to Project Managers

	Value	df	Asymp. Sig. "(2-sided)
Pearson Chi-Square	1.515[a]	4	.824
Likelihood Ratio	1.954	4	.744
Linear-by-Linear Association	.004	1	.951
N of Valid Cases	49		

a. 6 cells (60.0%) have expected count less than 5. The minimum expected count is .49.

Summary Project managers indicated that facilitation training could increase project success. A greater number of projects were reported with more facilitation training. However, the null hypothesis could not be rejected, so facilitation training does not directly impact project success.

RE10: Have you had any education around facilitation tools and techniques?

Requirements engineers were asked how much education or training related to facilitation they personally had received. For requirements engineers, 42.5% indicated they had no training with facilitation, 27.5% indicated they had some training with facilitation, 25% indicated they had little training, and 5% indicated they had much training with facilitation. Of the projects where the requirements engineer had much facilitation training, 100% succeeded. Of projects where the requirements engineer had little training with facilitation, 70% succeeded. Of projects where the requirements engineer had no training with facilitation, 64.7% succeeded. Of projects where the requirements engineer had some training with facilitation, 63.6% succeeded. These data do not have the same trend as the responses from project managers, but it does indicate that some training with facilitation may improve the chanced of project success. Table 77 provides the responses compared to project success.

Table 77 Project Success Compared to Facilitation Training Submitted by Requirements Engineers

		Project success or failure				Total
		Successful	% Success	Failure	% Failure	
Have you had any education around facilitation tools and techniques?	No training with facilitation	11	64.7	6	35.3	17
	Little training with facilitation	7	70	3	30	10
	Some training with facilitation	7	63.6	4	36.4	11
	Much training with facilitation	2	100	0	100	2
Total		27	67.5	13	32.5	40

Figure 42 shows that those with much facilitation training were connected mostly with very successful projects. Also, those with little facilitation training were represented more in more successful projects.

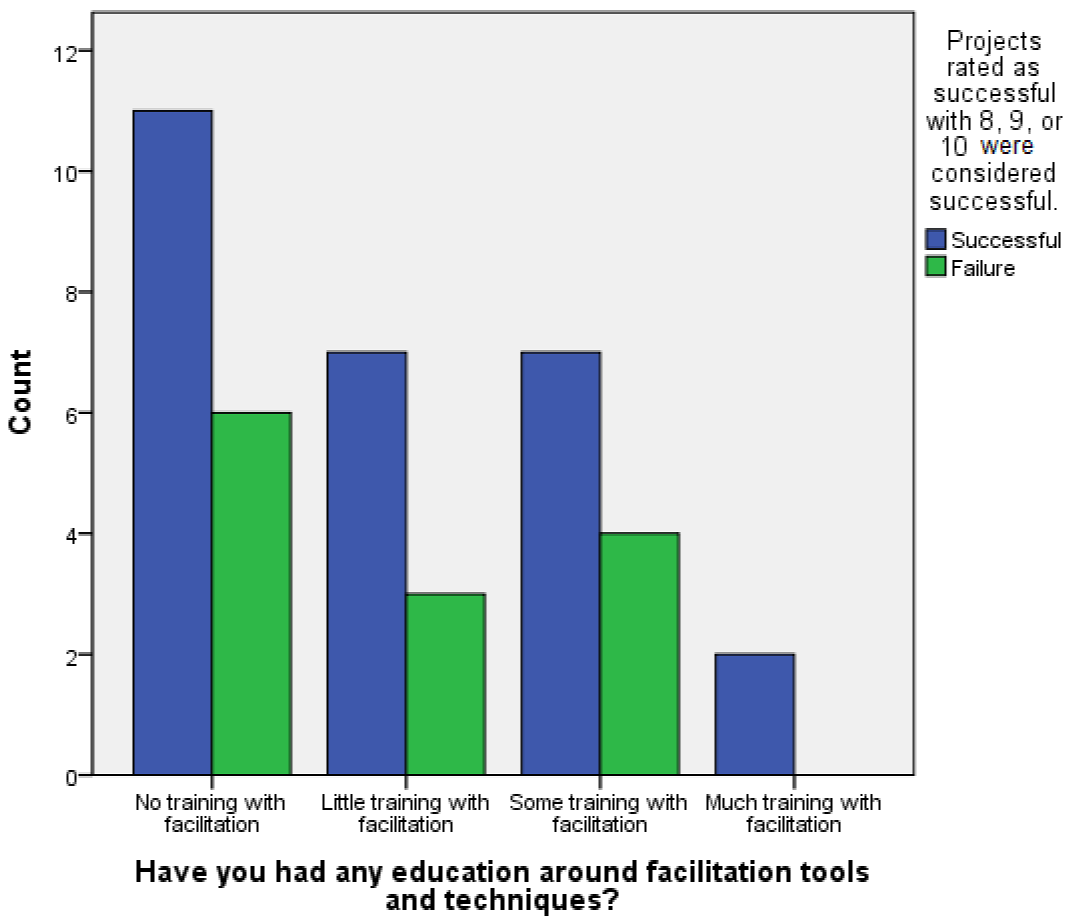

Figure 42 Project Success Compared to Facilitation Training Submitted by Requirements Engineers

These data were reviewed for statistical significance. The null hypothesis could not be rejected. A χ^2 value of 7.815 would be needed to reject the null hypothesis with 95% confidence. A χ^2 value of 1.127 was calculated for these data which is well below 7.815. A p-value of 0.771 was calculated which is inconclusive. Facilitation training does not directly affect project success. Table 78 shows the results of the chi-square analysis.

Table 78 Test of Null Hypothesis of Project Success Compared to Facilitation Training Submitted by Requirements Engineers

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.127[a]	3	.771
Likelihood Ratio	1.734	3	.629
Linear-by-Linear Association	.226	1	.635
N of Valid Cases	40		

a. 4 cells (50.0%) have expected count less than 5. The minimum expected count is .65.

<u>Summary</u> Requirements engineers reported a slight improvement in project success with more facilitation training. However, there was no trend of more success with more training as with the responses from project managers. Additionally, the null hypothesis could not be rejected. This means that the amount of facilitation training does not determine project success.

<u>RE11: Have you ever served as a facilitator in any situation?</u>

This question was posed only to requirements engineers. This data would have been difficult for project managers to provide as few have access to the resume(s) of the project team members. Furthermore, facilitation experience may not have been included in resume(s). The requirements engineers know their own experiences and would be able to provide more accurate information. The requirements engineers were asked how often they had served as a facilitator. Among requirements engineers, 42.5% indicated they have served as facilitator infrequently or have assisted in a facilitation session, 30% indicated they regularly serve as facilitator, 22.5% have never served as facilitator, and 5% frequently serve as facilitator. The group in which requirements engineer had never served as facilitator and the group in which the requirements engineer regularly serves as a facilitator had 66.7% successful projects. Of the projects where the requirements engineer has infrequently served as facilitator, 70.6% of the projects succeeded. Of the projects with a where the requirements engineer served frequently as facilitator, 50% finished successfully, but there was only two responses in this category . There may be some benefit for the requirements engineer serve as a facilitator infrequently, but there does not appear to be a trend such that the more someone conducts facilitation sessions, the more likely the project will succeed. Facilitation training is more beneficial than the experience of being a facilitator. Table 79 provides the responses compared to project success.

Table 79 Project Success Compared to Facilitation Experience Submitted by Requirements Engineers

		Project success or failure				
		Successful	% Successful	Failure	% Failure	Total
Have you ever served as a facilitator in any situation?	Never served as facilitator	6	66.7	3	33.3	9
	Infrequently serve as facilitator or assist with facilitation	12	70.6	5	29.4	17
	Regularly serve as facilitator	8	66.7	4	33.3	12
	Frequently serve as facilitator	1	50	1	50	2
Total		27	67.5	13	32.5	40

Figure 43 shows that the more successful projects were predominently comprised of those who infrequently serve as a facilitator.

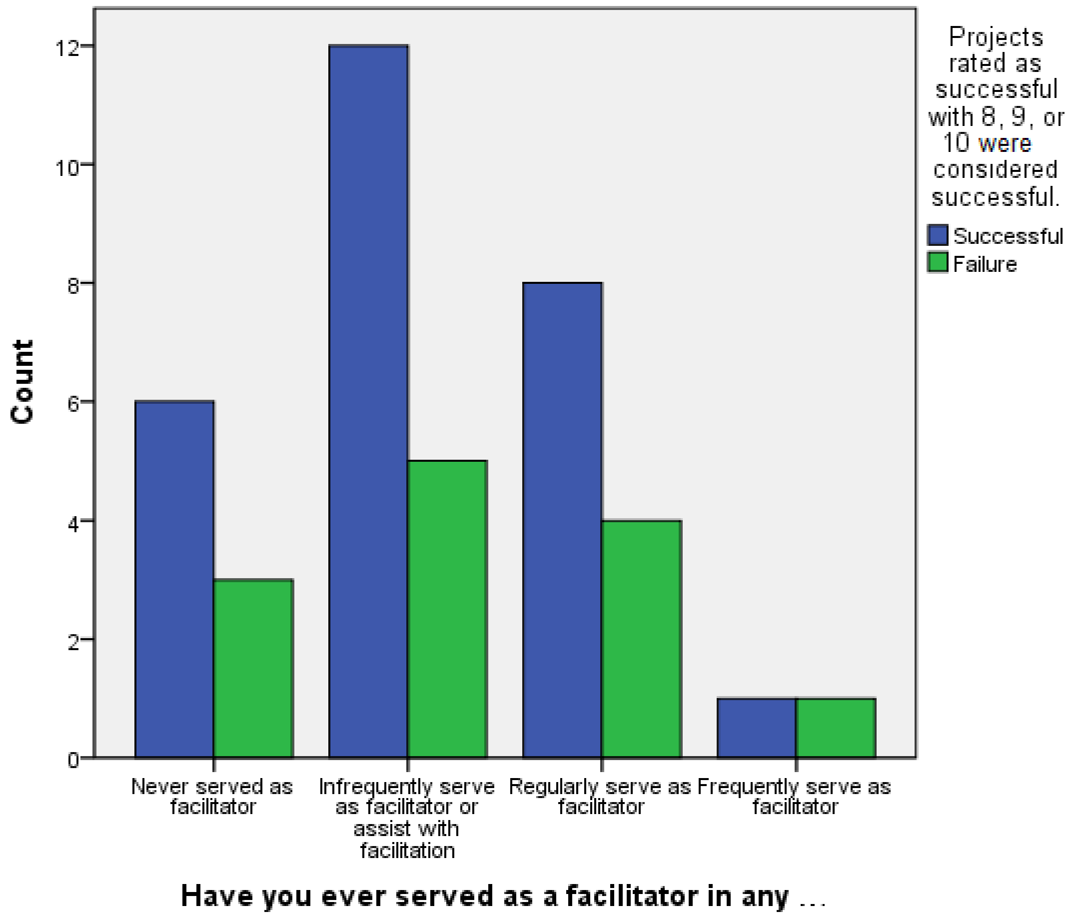

Figure 43 Project Success Compared to Facilitation Experience Submitted by Requirements Engineers

The data were analyzed for statistical significance. The null hypothesis could not be rejected. A χ^2 value of 7.815 would be needed to reject the null hypothesis with 95% confidence. The data yielded a χ^2 value of 0.360. The p-value was 0.948 which is inconclusive. Therefore facilitation experience does not impact project success. Table 80 provides the results of the chi-square analysis.

Table 80 Test of Null Hypothesis of Project Success Compared to Facilitation Experience Submitted by Requirements Engineers

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.360[a]	3	.948
Likelihood Ratio	.343	3	.952
Linear-by-Linear Association	.084	1	.772
N of Valid Cases	40		

a. 4 cells (50.0%) have expected count less than 5. The minimum expected count is .65.

Summary There may be a slight improvement by having a requirements engineer with some facilitation experience serve on a project. However, there is not a great increase in success and the null hypothesis cannot be rejected. This means that facilitation experience does not directly impact project success.

PM29: Did any of those working on requirements have any education around tools and techniques of negotiation?

Like the questions related to facilitation training, project managers were asked their understanding of negotiation education/training levels of their project team members assigned to requirements analysis tasks. Little training with negotiation, some training with negotiation, and being unaware of any training on negotiation each received 24.5% of the responses. Of the responses, 22.4% had no training with negotiation and 4% had much training with negotiation. Of those with much training with negotiation, 100% of the projects succeeded. Of those projects where team members had little or some training on negotiation, 91.7% succeeded. Of those with no negotiation training, 81.8% of their projects succeeded. For those where it was unknown if they had any negotiation training, 66.7% of the projects succeeded. This indicates that negotiation training can increase the likelihood of project success. Table 81 provides the responses compared to project success.

Table 81 Project Success Compared to Negotiation Training of Team Members Working on Requirements According to Project Managers

		Project success or failure				
		Successful	% Successful	Failure	% Failure	Total
Did any of those working on requirements have any education/training around tools and techniques of negotiation?	No training with negotiation	9	81.8	2	18.1	11
	Little training with negotiation	11	91.7	1	8.3	12
	Some training with negotiation	11	91.7	1	8.3	12
	Much training with negotiation	2	100	0	0	2
	Don't Know	8	66.7	4	33.3	12
Total		41	83.7	8	16.3	49

In Figure 44, those with little or some training on negotiation a represented more frequently on successful projects.

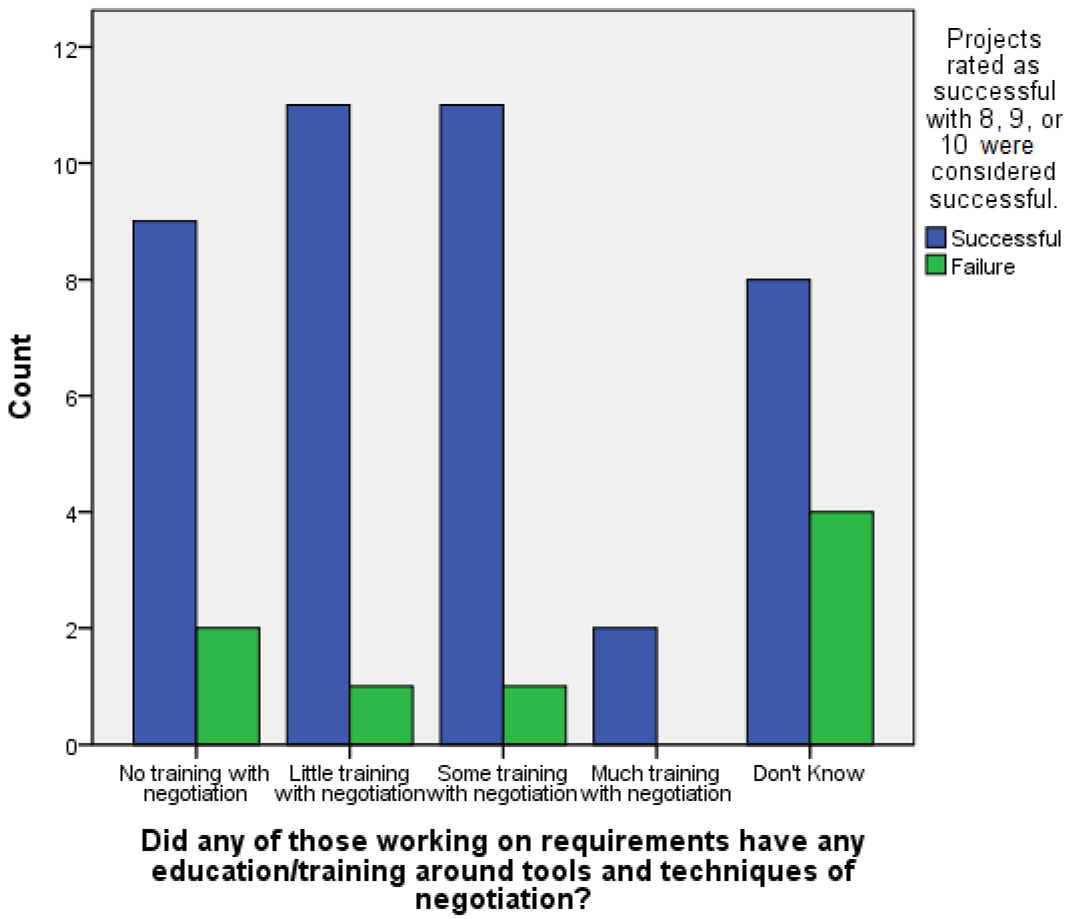

Figure 44 Project Success Compared to Negotiation Training of Team Members Working on Requirements According to Project Managers

This data were tested for statistical significance. The null hypothesis could not be rejected. A χ^2 value of 9.488 would be needed to reject the null hypothesis with 95% confidence. A χ^2 value of 4.081 was calculated for the data which is less than 9.488. The p-value was 0.395 which is inconclusive. Therefore training for negotiation does not impact project success. Table 82 shows the results of the chi-square analysis.

Table 82 Test of Null Hypothesis of Project Success Compared to Negotiation Training of Team Members Working on Requirements According to Project Managers

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.081[a]	4	.395
Likelihood Ratio	4.139	4	.388
Linear-by-Linear Association	1.270	1	.260
N of Valid Cases	49		

a. 6 cells (60.0%) have expected count less than 5. The minimum expected count is .33.

Summary There may be an improvement in project success when those working on requirements have some training related to negotiation. Even with little negotiation training, there was improvement in the number of successful projects. However, the null hypothesis cannot be rejected and therefore negotiation training does not directly impact project success.

RE12: Have you had any education around tools and techniques of negotiation?

Requirements engineers were asked how much education or training related to negotiation they personally had received. For requirements engineers, 45% indicated they had no training with negotiation, 14% indicated they had little training with negotiation, and 20% indicated they had some training. No one indicated they had much training with negotiation. Of projects where the requirements engineer had no training with negotiation, 77.8% succeeded. Of projects were the requirements engineer had some training with negotiation, 62.5% succeeded. Of projects where the requirements engineer had little training with negotiation, 57.1% succeeded. These data do not have the same trend as the responses from project managers. It does not indicate there is any trend with training for negotiation and the success of the project. Table 83 shows the responses compared to project success.

Table 83 Project Success Compared to Negotiation Training Submitted by Requirements Engineers

		Project success or failure				Total
		Successful	% Successful	Failure	% Failure	
Have you had any education around tools and techniques of negotiation?	No training with negotiation	14	77.8	4	22.2	18
	Little training with negotiation	8	57.1	6	42.9	14
	Some training with negotiation	5	62.5	3	37.5	8
Total		27	67.5	13	32.5	40

Figure 45 shows there is no trend that any training for negotiation can increase project success. For the more successful projects, requriements engineers with no training on negotiation were involved.

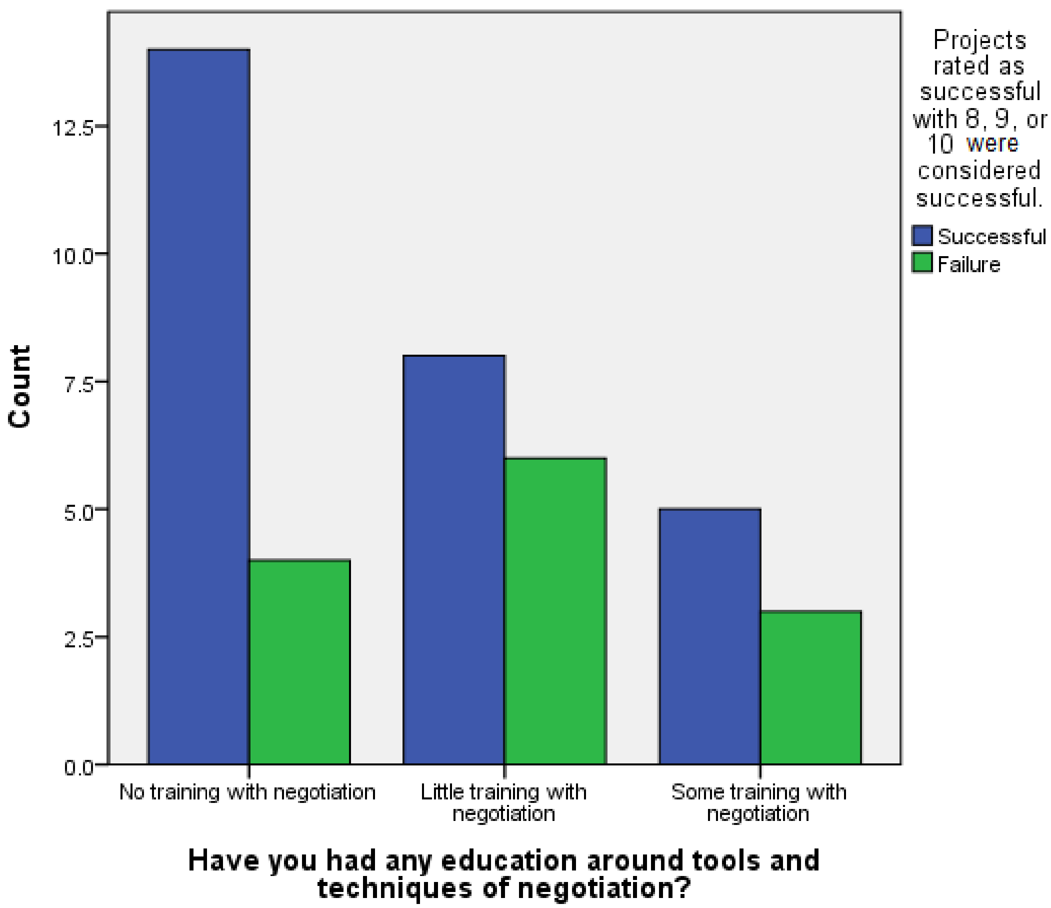

Figure 45 Project Success Compared to Negotiation Training Submitted by Requirements Engineers

The data were tested for statistical significance and the null hypothesis could not be rejected. A χ^2 value of 5.991 would be needed to reject the null hypothesis with 95% confidence. This data yielded a χ^2 value of 1.642. The p-value was 0.440 which is inconclusive. The level of training for negotiation does not impact project success. Table 84 contains the results of the chi-square analysis.

Table 84 Test of Null Hypothesis of Project Success Compared to Negotiation Training Submitted by Requirements Engineers

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.642[a]	2	.440
Likelihood Ratio	1.671	2	.434
Linear-by-Linear Association	.957	1	.328
N of Valid Cases	40		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 2.60.

Summary Most requirements engineers did not have any training related to negotiation. For those who did, they did not have an increase in project success. The null hypothesis also could not be rejected indicating that negotiation training does not impact project success.

RE13: Have you ever served as a negotiator or mediator in any situation?

This question was posed only to requirements engineers. These data would have been difficult for project managers to provide as few have access to the resume(s) of the project team members. Furthermore, negotiation experience may not have been included in resume(s). The requirements engineers know their own experiences and would be able to provide more accurate information. The requirements engineers were asked how often they had served as a negotiator. Among requirements engineers, 50% indicated they have served as negotiator infrequently or have assisted in a negotiation session, 42.5% have never served as negotiator, and 7.5% indicated they regularly serve as negotiator. Of the projects where the requirements engineer has infrequently served as negotiator, 70% of the projects succeeded. The group in which requirements engineer regularly serves as a negotiator had 66.7% of the projects to succeed. Of the projects with a where the requirements engineer never served as negotiator, 64.7% succeeded. There may be some benefit for the requirements engineer serve as a negotiator infrequently, but there does not appear to be a trend such that the more someone conducts negotiation sessions, the more likely the project will succeed. Negotiation training is more beneficial than the experience of being a negotiator. Table 85 shows the responses compared to project success.

Table 85 Project Success Compared to Negotiation Experience Submitted by Requirements Engineers

		Project success or failure				Total
		Successful	% Successful	Failure	% Failure	
Have you ever served as a negotiator or mediator in any situation?	Never served as negotiator	11	64.7	6	35.3	17
	Infrequently serve as negotiator or assist with negotiation	14	70	6	30	20
	Regularly serve as negotiator	2	66.7	1	33.3	3
Total		27	67.5	13	32.5	89

Figure 46 shows that the more successful projects had a requirements engineer who had severed as a negotiator infrequently.

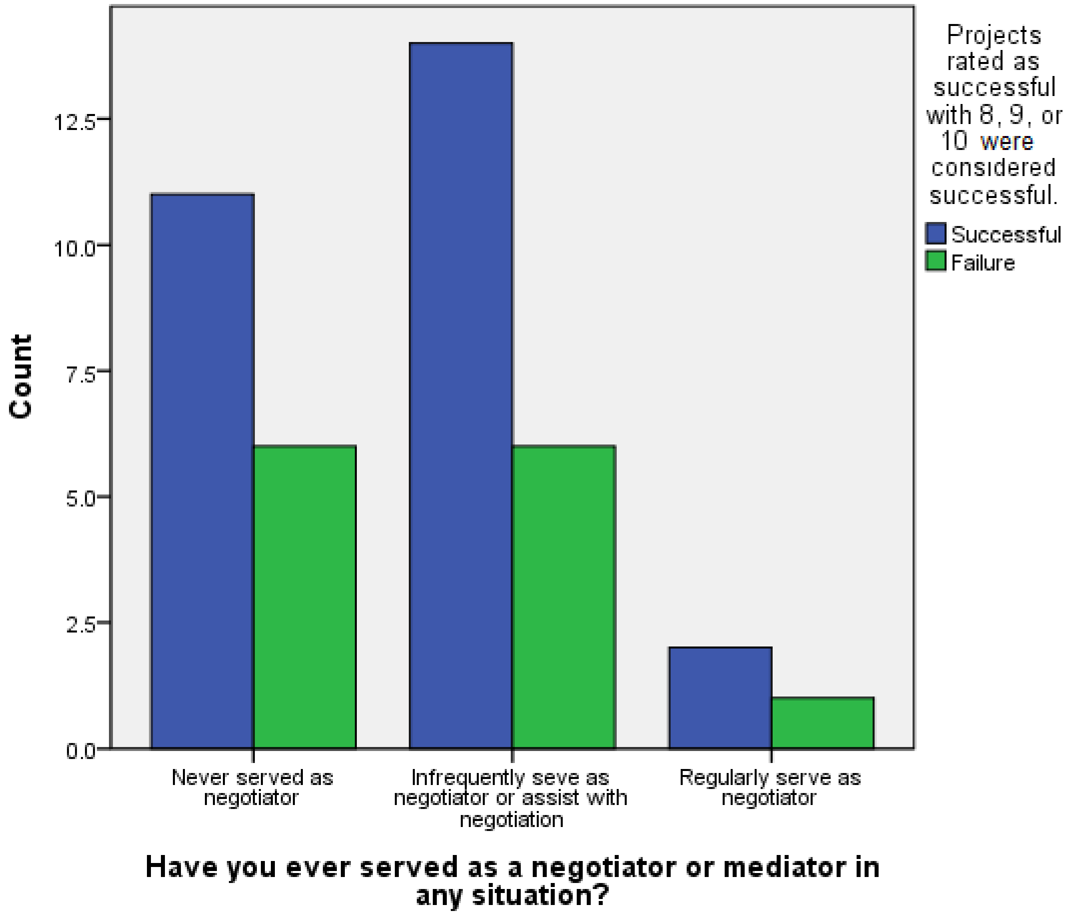

Figure 46 Project Success Compared to Negotiation Experience Submitted by Requirements Engineers

The data were also analyzed for statistical significance. The null hypothesis could not be rejected. The χ^2 value needed to reject the null hypothesis with 95% confidence is 5.991. This data yielded a χ^2 value of 0.118. The p-value was 0.943 which is inconclusive. Therefore the amount of negotiation experience does not impact project success. Table 86 shows the results of the chi-square analysis.

Table 86 Test of Null Hypothesis of Project Success vs. Negotiation Experience Submitted by Requirements Engineers

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.118[a]	2	.943
Likelihood Ratio	.118	2	.943
Linear-by-Linear Association	.060	1	.807
N of Valid Cases	40		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is .98.

Summary There were no trends among the requirements engineers' responses that serving as a negotiator increases project success. Additionally, the null hypothesis could not be rejected and so negotiation experience does not impact project success.

Appendix D: Validating Project Success

Respondents were asked to rate the success of their project(s) on a scale of 1 to 10 with 1 meaning the project was a failure and 10 meaning the project was very successful. This rating needs to be validated against project measures to determine if the projects were in fact successful. These measures include: whether the project finished on time; whether the project finished using the planned amount of effort; whether the project finished on budget; whether the scope was defined and if items in scope were delivered; whether there was a change request process in place; whether the customer was satisfied with the final deliverables; whether the customer was using or had plans to use the final deliverables; and whether the customers organization was positively impacted by the final deliverables.

PM11 / RE14: How successful was this project in your opinion (scale of 1 to 10 with 10 being very successful)?

Most respondents indicated their projects succeeded. The median response was a 9 on a scale from 1 to 10 with 10 representing a very successful project. Table 87 shows the median and standard deviation.

Table 87 Median and Standard Deviation of Project Success Rates

Median	9.00
Std. Deviation	1.866

Of projects, 22.5% were rated as 10. Of the projects, 76.4% were rated as an 8, 9, or 10. There is a 15.7% difference between projects rated as 8 and those rated as 7. Because of the significant difference between these two ratings, projects rated as 8, 9, or 10 will be considered successful projects. Several measures were reviewed to show whether a successful project rating is justified. Additionally, completing within 10% of the project measure goal is deemed acceptable in the project management profession (McConnell, 1998). For each of these measures, it is expected that approximately Of projects 76.4% will have completed within 10% of the project goal (e.g. no more than 10% over budget).

Otherwise, a successful rating may not be justified. Table 88 shows the success ratings assigned to projects.

Table 88 Success Rates Assigned to Projects

Rating	Frequency	Percent
1 - Failure, Not Successful	2	2.3
4	1	1.1
5	8	9.0
6	2	2.3
7	8	9.0
8	22	24.7
9	26	29.2
10 - Very Successful	20	22.5
Total	89	100.1

Figure 47 below shows the distribution of project success rating for all responses. This includes information from all respondents, both Project Managers and Requirements Engineers.

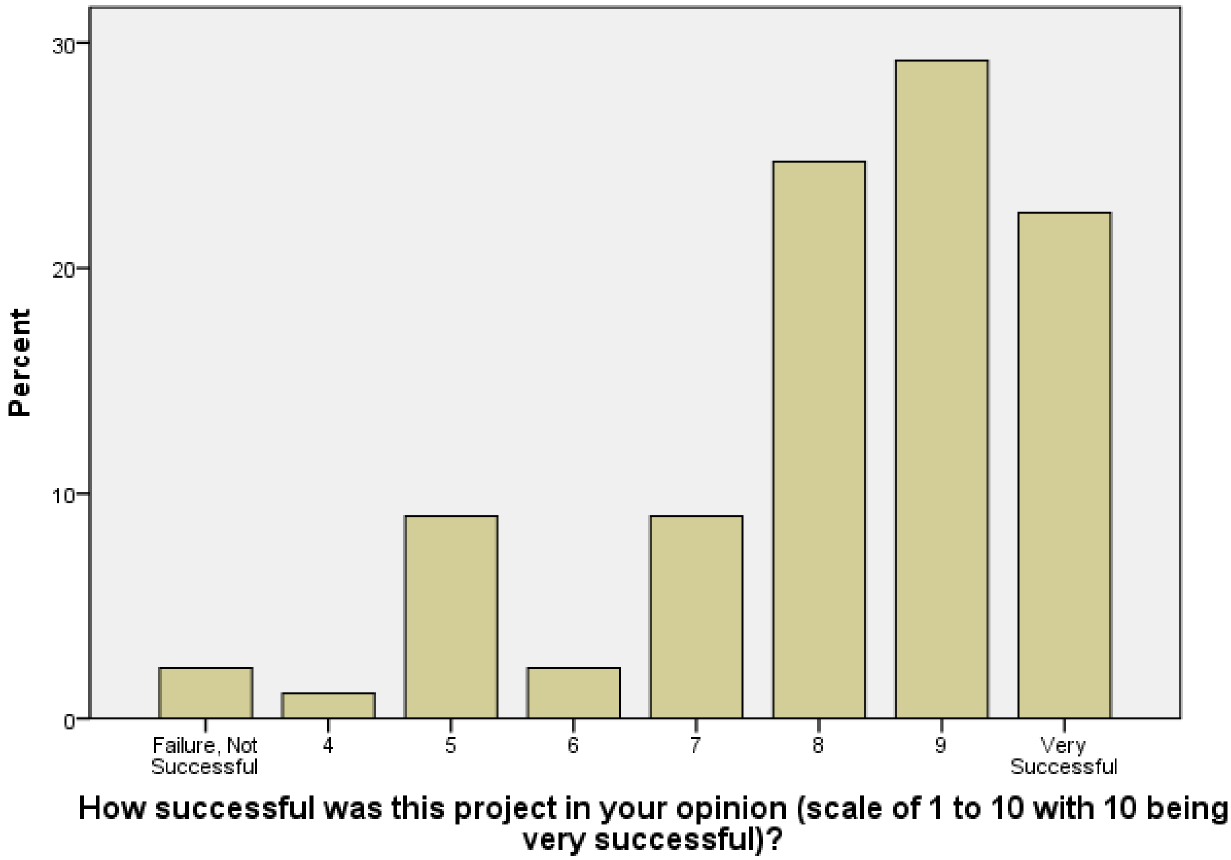

Figure 47 Distribution of Project Success Rates

When responses are reviewed by whether the respondent was a Project Manager or a Requirements Engineer, we see that the responses between the two groups are consistent. Both Project Managers and Requirements Engineers mostly submitted information for projects they viewed as successful. Figure 48 shows the ratings submitted by project managers and requirements engineers.

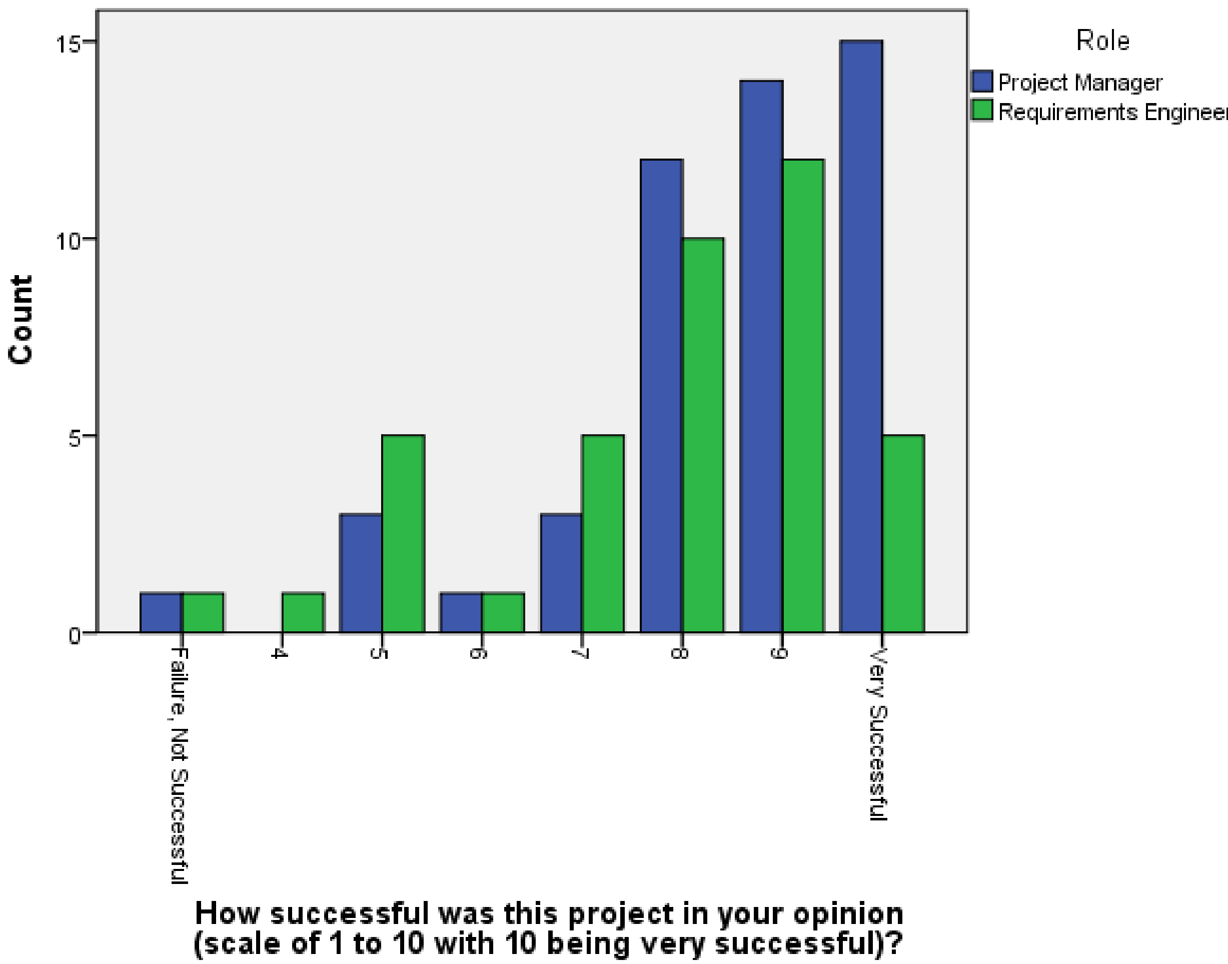

Figure 48 Distribution of Success Rates by Project Managers and Requirements Engineers

PM13 / RE16: Was this project able to complete in the time scheduled?

One characteristic or measure to determine if a project is successful is whether or not the project was able to finish on the planned completion date. This was one of the measures used in the Chaos Report from the Standish Group (Standish, 1999). Of the responses, 53.9% of the projects finished early or on time. This is a 22.5% discrepancy between the 76.4% projects rated as 8, 9, or 10. Of the projects rated as 10 on the project success scale, 90% finished early or on time. Of the projects that received a 9 on the project success scale, 50% finished early or on time. Of the projects that were rated as 8, 9, or 10, 60.3% were completed early or on time. Of projects, 80.9% were completed no more than 10% beyond the planned finish date. This indicates that those projects that were marked as most successful were able to finish on or very close to their planned finish date and therefore the success rating is valid for this measure. Table 89 shows the success ratings compared to completion dates.

Table 89 Project Success Rates Compared to Project Completion Dates

		Was this project able to complete in the time scheduled?							
		Finished early	Finished on time	Finished 1-10% beyond the planned finish date	Finished 11-25% beyond the planned finish date	Finished 26-50% beyond the planned finish date	Finished more than 50% beyond the planned finish date	Don't Know	Total
How successful was this project in your opinion (scale of 1 to 10 with 10 being very successful)?	Failure, Not Successful	0	0	0	0	0	1	1	2
	4	0	0	1	0	0	0	0	1
	5	0	3	3	0	2	0	0	8
	6	0	1	1	0	0	0	0	2
	7	0	3	2	3	0	0	0	8
	8	1	9	7	4	1	0	0	22
	9	3	10	9	3	1	0	0	26
	Very Successful	2	16	1	0	0	1	0	20
Total		6	42	24	10	4	2	1	89

Figure 49 shows the responses of when the project with the project success rating shows that projects with higher success ratings predominantly finished no more than 10% beyond the planned finish date with most finishing on time.

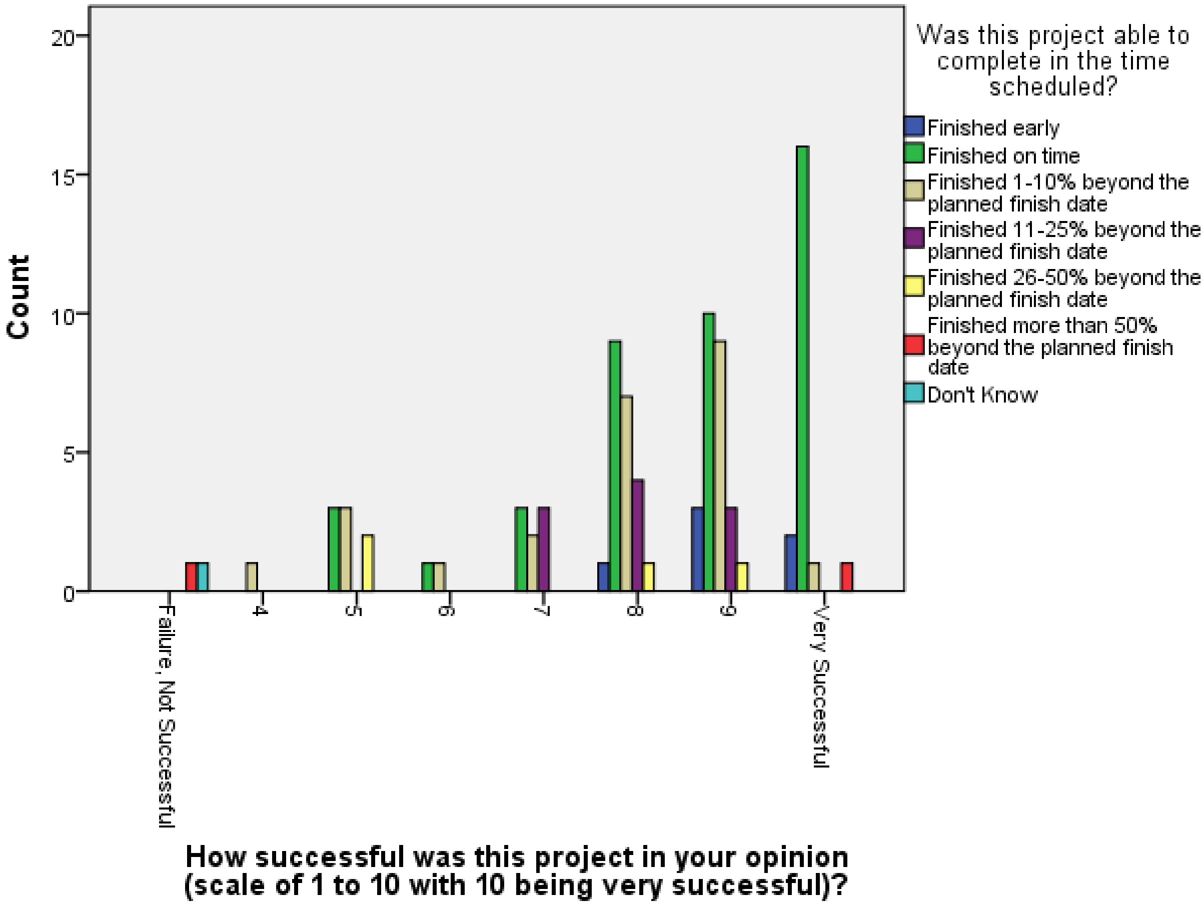

Figure 49 Project Success Rates Compared to Project Completion Dates

If projects rated as 8, 9, and 10 are categorized as successful and all others are failures, the following is a comparison of success to time to completion. Table 90 shows project success compared to completion time.

Table 90 Projects Success Compared to Project Completion Time

		Projects rated as successful with 8, 9, or 10 were considered successful.		
		Successful	Failure	Total
Was this project able to complete in the time scheduled?	Finished early	6	0	6
	Finished on time	35	7	42
	Finished 1-10% beyond the planned finish date	17	7	24
	Finished 11-25% beyond the planned finish date	7	3	10
	Finished 26-50% beyond the planned finish date	2	2	4
	Finished more than 50% beyond the planned finish date	1	1	2
	Don't Know	0	1	1
Total		68	21	89

Analyzing the data to determine the impact time to completion had on project success shows that a χ^2 value of 10.645 is needed to reject the null hypothesis with 90% confidence. The χ^2 value for these data is 9.171 which is less than 10.645 and therefore the null hypothesis cannot be rejected. A χ^2 value of 8.558 would be needed to reject the null hypothesis with 80% confidence. These data do meet that criterion. There is a strong correlation between time completed and project success, but finishing on time does not determine project success. Table 91 provides the results of the chi-square analysis.

Table 91 Test of Null Hypothesis of Project Success Compared to Time to Completion

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.171[a]	6	.164
Likelihood Ratio	9.898	6	.129
Linear-by-Linear Association	7.991	1	.005
N of Valid Cases	89		

a. 9 cells (64.3%) have expected count less than 5. The minimum expected count is .24.

PM14 / RE17: Was this project able to complete within the planned amount of effort?

If projects are behind schedule and cannot finish on time, Project Managers may choose to fast track or crash the project. Fast tracking involves having resources increase their effort and possibly work overtime to complete the work on schedule. Crashing involves adding more resources so that the work can be completed on time. Either of these choices is an increase in the amount of effort to complete the project and may lead to an increase in the final cost for the project (PMBOK, 2008). Another measure of project success is whether the project is also able to use the amount of effort originally planned to meet the scheduled delivery date. Of the responses, 36.1% of projects were able to finish using the planned amount of effort or less. This is a 40.3% discrepancy between the 76.4% of projects rated as 8, 9, or 10. For projects rated as 10, 70% finished using the planned amount of effort or less. For projects rated as a 9, only 50% were able to finish using the planned amount of effort or less. Of the projects rated as 8, 9, or 10, 52.9% were able to complete using the planned amount of effort of less. Of all projects, 79.7% were able to finish using no more than 10% more than the planned amount of effort. This indicates that those projects that were marked as most successful were able to finish at or very close to their planned level of effort and therefore the success rating is valid for this measure. Table 92 shows project success rates compared to the planned amount of effort.

Table 92 Project Success Rates Compared to Planned Amount of Effort

		Was the project complete within the planned amount of effort?							Total
		Finished using less effort	Finished using the planned level of effort	Finished using 1-10% more effort than planned	Finished using 11-25% more effort than planned	Finished using 26-50% more effort than planned	Finished using over 50% more effort than planned	Don't Know	
How successful was this project in your opinion (scale of 1 to 10 with 10 being very successful)?	Failure, Not Successful	0	0	0	0	0	1	1	2
	4	0	0	0	1	0	0	0	1
	5	0	3	3	0	0	2	0	8
	6	0	0	1	0	1	0	0	2
	7	1	1	2	3	1	0	0	8
	8	0	9	10	1	2	0	0	22
	9	0	13	9	2	1	1	0	26
	Very Successful	4	10	5	0	1	0	0	20
Total		5	36	30	7	6	4	1	89

Figure 50 shows that projects rated as 9 or 10 predominantly finished using the planned amount of effort. For projects rated as an 8, an almost equal amount of projects were finished using 1-10% more effort and using the planned amount of effort.

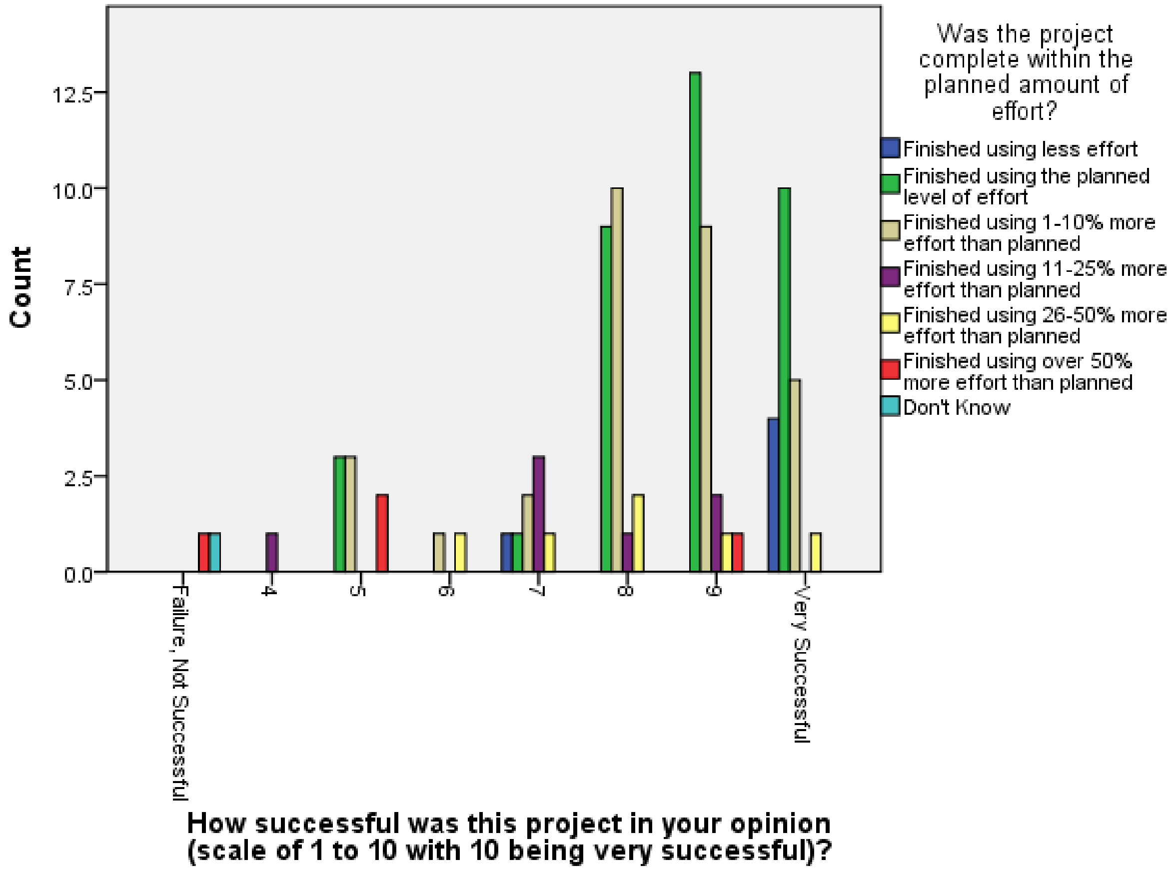

Figure 50 Project Success Rates Compared to Planned Amount of Effort

Below shows the data by categorizing success ratings of 8, 9, or 10 as successful and all others as failures and compared to the amount of effort needed. Table 93 shows the planned amount of effort compared to the success and failure categories.

Table 93 Project Success Compared to Planned Amount of Effort

		Projects rated as successful with 8, 9, or 10 were considered successful.		
		Successful	Failure	Total
Was the project complete within the planned amount of effort?	Finished using less effort	4	1	5
	Finished using the planned level of effort	32	4	36
	Finished using 1-10% more effort than planned	24	6	30
	Finished using 11-25% more effort than planned	3	4	7
	Finished using 26-50% more effort than planned	4	2	6
	Finished using over 50% more effort than planned	1	3	4
	Don't Know	0	1	1
Total		68	21	89

We can then analyze the data for statistical significance. A χ^2 value of 12.592 would be needed to reject the null hypothesis with 95% confidence. A χ^2 value of 16.812 would be needed to reject the null hypothesis with 99% confidence. This data set yielded a χ^2 value of 17.150 which is enough to reject the null hypothesis with 99% confidence. The amount of effort does directly affect project success. Table 94 shows the results of the chi-square analysis.

Table 94 Test of Null Hypothesis of Project Success Compared to Planned Amount of Effort

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	17.150[a]	6	.009
Likelihood Ratio	15.413	6	.017
Linear-by-Linear Association	12.337	1	.000
N of Valid Cases	89		

a. 9 cells (64.3%) have expected count less than 5. The minimum expected count is .24.

PM15 / RE18: Was this project able to complete within budget?

Another measure of project success is whether or not the project was completed within the budget allocated. Of projects, 66.3% finished on or under budget. This is a 10.1% discrepancy between the 76.4% of projects rated as 8, 9, or 10. For projects rated as 10, 85% finished on or under budget. For projects rated as a 9, 61.5% were finished on or under budget. Of the projects rated as 8, 9, or 10, 69.1% were able to finish on or under budget. Among all projects, 85.4% were able to finish using no more than 10% over budget. This indicates that those projects that were marked as most successful were able to finish on or very close to their budget and therefore the success rating is valid for this measure. Table 95 shows project success rates compared to the project budget at completion.

Table 95 Project Success Rates Compared to Completing Within Budget

		Was this project able to complete within budget?						Total
		Finished under budget	Finished as budgeted	Finished 1-10% over budget	Finished 11-25% over budget	Finished 26-50% over budget	Don't Know	
How successful was this project in your opinion (scale of 1 to 10 with 10 being very successful)?	Failure, Not Successful	0	0	0	0	1	1	2
	4	0	0	0	1	0	0	1
	5	0	6	1	0	1	0	8
	6	0	1	0	0	1	0	2
	7	2	3	2	1	0	0	8
	8	3	11	6	0	2	0	22
	9	2	14	5	4	0	1	26
	Very Successful	6	11	3	0	0	0	20
Total		13	46	17	6	5	2	89

Figure 51 shows that projects rated 8, 9, and 10 were predominantly finished as budgeted. For projects rated as 10, the next most frequent status is that the project finished under budget. For projects rated as 8, the second most frequent is 1-10% over budget.

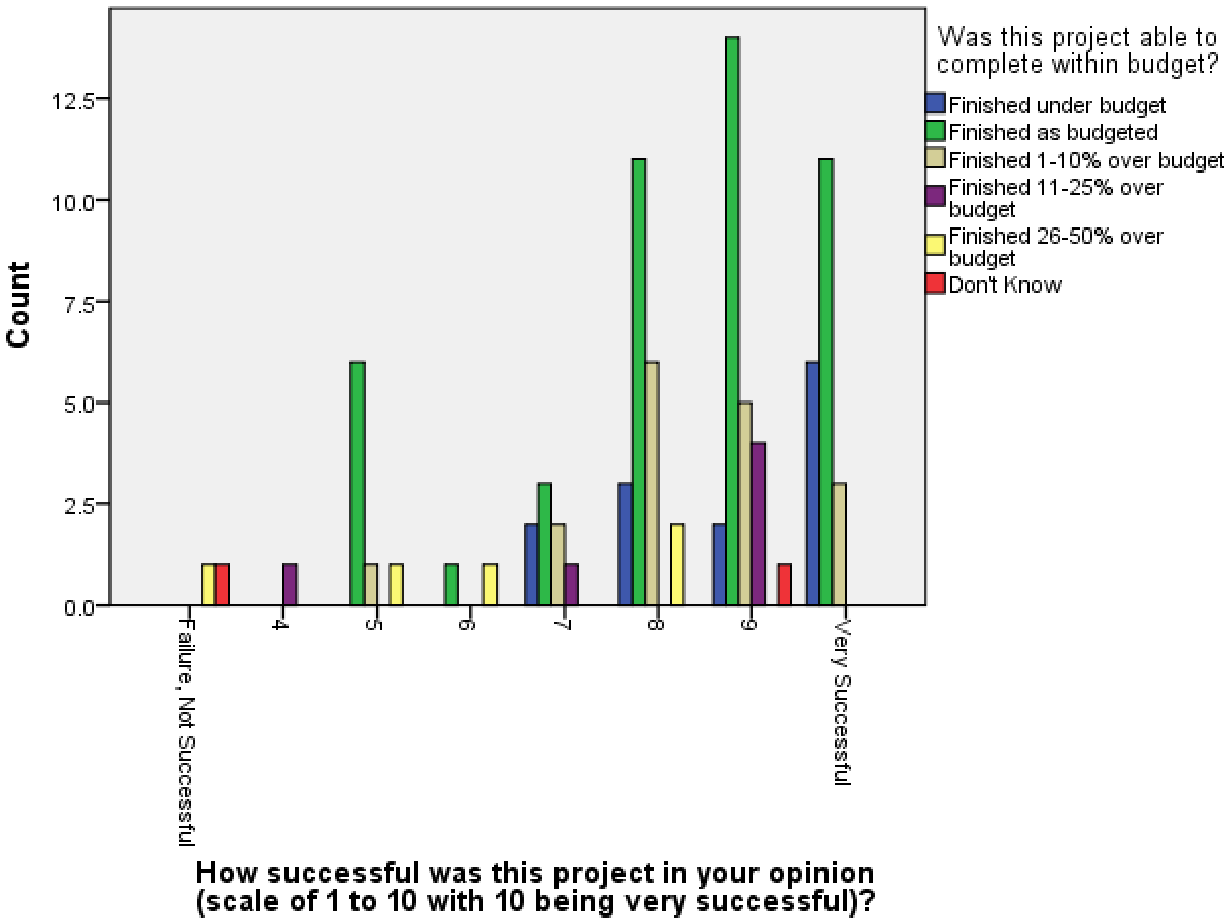

Figure 51 Project Success Rates Compared to Completing Within Budget

Table 96 below shows the data by categorizing projects rated as 8, 9, or 10 as successful and all others as failures.

Table 96 Project Success Compared to Completing Within Budget

		Projects rated as successful with 8, 9, or 10 were considered successful.		
		Successful	Failure	Total
Was this project able to complete within budget?	Finished under budget	11	2	13
	Finished as budgeted	36	10	46
	Finished 1-10% over budget	14	3	17
	Finished 11-25% over budget	4	2	6
	Finished 26-50% over budget	2	3	5
	Don't Know	1	1	2
Total		68	21	89

Analyzing the data to determine statistical significance shows that a χ^2 value of 11.070 would be needed to reject the null hypothesis with 95% confidence. The data yielded a χ^2 value of 5.672. This is not enough to reject the null hypothesis. This is only enough to reject the null hypothesis with 50% confidence, so there is not a strong correlation between budget and project success. Table 97 provides the results of the chi-square analysis.

Table 97 Test of the Null Hypothesis of Completing Within Budget Compared to Project Success

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.672[a]	5	.339
Likelihood Ratio	4.937	5	.424
Linear-by-Linear Association	3.666	1	.056
N of Valid Cases	89		

a. 8 cells (66.7%) have expected count less than 5. The minimum expected count is .47.

PM16 / RE19: Was the scope of this project well defined?

Project success can also be measured by scope. Without a defined scope for the project, there is no agreement on what will be delivered with the project. Of projects, 68.5% had a well-defined or very well-defined scope. This is a 7.9% discrepancy between the 76.4% of projects rated as 8, 9, or 10. For projects rated as 10, 85% had a well-defined or very well defined scope. For projects rated as a 9, 76.9% had a well-defined or very well defined scope. Of the projects rated as 8, 9, or 10, 77.9% had a well-defined or very well defined scope. This indicates that those projects that were marked as most successful did define their scope and therefore the success rating is valid for this measure. Table 98 compares project success rates to the scope definition.

Table 98 Project Success Rates Compared to Scope Definition

		Was the scope of this project well-defined?				
		Not Defined	Somewhat Defined	Well Defined	Very Well Defined	Total
How successful was this project in your opinion (scale of 1 to 10 with 10 being very successful)?	Failure, Not Successful	0	2	0	0	2
	4	0	1	0	0	1
	5	2	4	2	0	8
	6	0	1	1	0	2
	7	0	3	5	0	8
	8	0	6	14	2	22
	9	0	6	15	5	26
	Very Successful	0	3	12	5	20
Total		2	26	49	12	89

Figure 52 shows that the most successful projects (rated 8, 9, or 10) predominantly had well-defined scopes.

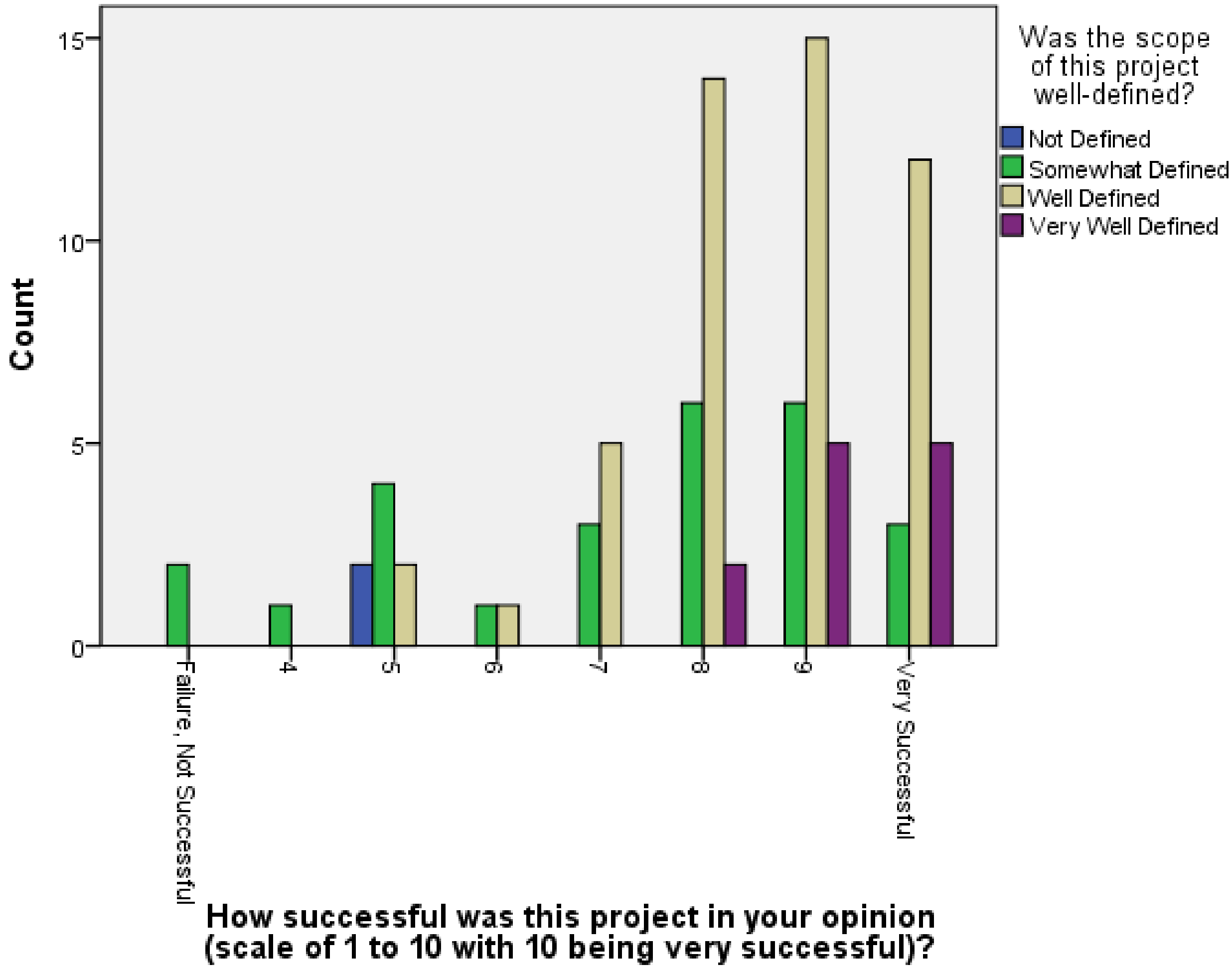

Figure 52 Project Success Rates Compared to Scope Definition

Table 99 below shows the data by categorizing the project rating with 8,9, or 10 as successful and all others as failures.

Table 99 Project Success Compared to Scope Definition

		Projects rated as successful with 8, 9, or 10 were considered successful.		
		Successful	Failure	Total
Was the scope of this project well-defined?	Not Defined	0	2	2
	Somewhat Defined	15	11	26
	Well Defined	41	8	49
	Very Well Defined	12	0	12
Total		68	21	89

These data can then be analyzed to determine statistical significance. A χ^2 value of 7.815 would be needed to reject the null hypothesis with 95% confidence. This data yielded a χ^2 value of 16.668. This means the null hypothesis can be rejected with 99.9% confidence as a χ^2 value of 16.268 is needed to reject the null hypothesis at this level. This means that scope definition directly impacts project success. Table 100 provides the results of the chi-square analysis.

Table 100 Test of Null Hypothesis of Project Success Compared to Scope Definition

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	16.668[a]	3	.001
Likelihood Ratio	18.214	3	.000
Linear-by-Linear Association	14.971	1	.000
N of Valid Cases	89		

a. 3 cells (37.5%) have expected count less than 5. The minimum expected count is .47.

PM17 / RE20: Was the scope of the project met?

Delivering the items as defined within the scope of the project is a measure of quality for a project. This is a way to determine if the project met the customer's expectations. Of projects, 80.9% delivered all items as defined in the scope. This is a 4.5% discrepancy between the 76.4% of projects rated as 8, 9, or 10. This is also the first measure where more projects had a positive value for the measure than the number of projects rated as successful. For projects rated as 10, 90% finished delivering all items as identified in the scope. Of the projects rated 10, 100% delivered items defined in scope or more. For projects rated as a 9, 92.3% finished delivering all items as identified in the scope. Like the projects rated as 10, also 100% of the projects rated as 9 delivered items defined in scope or more. Of the projects rated as 8, 9, or 10, 97.1% were able to deliver what was defined in the scope or more. Of all projects, 91.0% were able to deliver what was defined in the scope or more. This indicates that those projects that were marked as most successful delivered the items defined in the scope and therefore the success rating is valid for this measure. Table 101 shows project rates compared to meeting scope.

Table 101 Project Success Rates Compared to Meeting Scope

		Was the scope of the project met?					
		Yes, all items were delivered as defined in the scope	No, fewer items were delivered than defined in the scope	No, more items were delivered than defined in the scope	Scope was not met for the project	Don't Know	Total
How successful was this project in your opinion (scale of 1 to 10 with 10 being very successful)?	Failure, Not Successful	0	0	0	1	1	2
	4	1	0	0	0	0	1
	5	6	1	0	1	0	8
	6	1	1	0	0	0	2
	7	5	1	2	0	0	8
	8	17	2	3	0	0	22
	9	24	0	2	0	0	26
	Very Successful	18	0	2	0	0	20
Total		72	5	9	2	1	89

Figure 53 shows that the most successful projects predominantly deliver items as defined in the scope for the project.

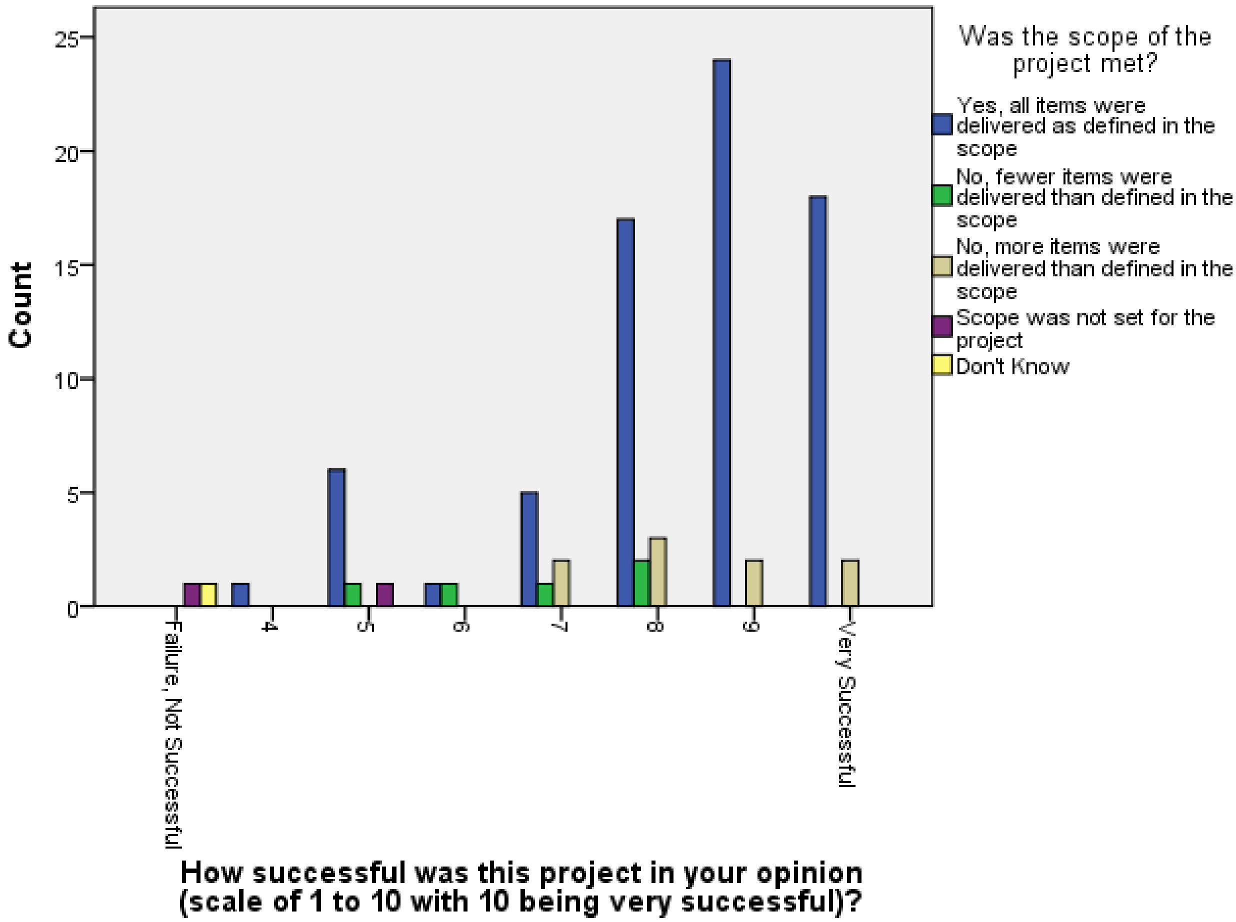

Figure 53 Project Success Rates Compared to Meeting Scope

Table 102 shows the data with project ratings 8, 9, or 10 categorized as successful and all others as failures.

Table 102 Project Success Compared to Meeting Project Scope

		Projects rated as successful with 8, 9, or 10 were considered successful.		Total
		Successful	Failure	
Was the scope of the project met?	Yes, all items were delivered as defined in the scope	59	13	72
	No, fewer items were delivered than defined in the scope	2	3	5
	No, more items were delivered than defined in the scope	7	2	9
	Scope was not set for the project	0	2	2
	Don't Know	0	1	1
Total		68	21	89

Analyzing the data for statistical significance shows that a χ^2 value of 9.488 would be needed to reject the null hypothesis with 95% confidence. This data has a χ^2 value of 14.625. This is enough to reject the null hypothesis with 99% confidence (13.277 χ^2 value or higher). Meeting project scope directly impacts project success. Table 103 provides the results of the chi-square analysis.

Table 103 Test of Null Hypothesis of Project Success Compared to Meeting Project Scope

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	14.625[a]	4	.006
Likelihood Ratio	12.988	4	.011
Linear-by-Linear Association	7.418	1	.006
N of Valid Cases	89		

a. 7 cells (70.0%) have expected count less than 5. The minimum expected count is .24.

PM18 / RE21: Was there a plan in place to manage change requests?

Requests for changes frequently occur during a project. A plan needs to be in place to handle these changes and determine how they should impact the project. Failing to manage these requests leads to situations such as scope creep. Among projects, 49.4% had a well-documented plan in place and 28.1% of projects had a plan, but it wasn't well-documented. A total of 77.5% of projects did have a plan of some kind. Of projects that were rated 8, 9, or 10, 85.3% had some kind of plan in place. This indicates that those projects that were marked as most successful did have some change request process in place and therefore the success rating is valid for this measure. Table 104 compares project success rates to change request plans.

Table 104 Project Success Rates Compared to Changes Request Plans

		Was there a plan in place to manage changes (change controls)?			
		No change management plan was put in place	A plan was in place, but not well documented	A well-documented plan was in place	Total
How successful was this project in your opinion (scale of 1 to 10 with 10 being very successful)?	Failure, Not Successful	2	0	0	2
	4	0	1	0	1
	5	5	2	1	8
	6	0	1	1	2
	7	3	3	2	8
	8	3	9	10	22
	9	4	9	13	26
	Very Successful	3	0	17	20
Total		20	25	44	89

Figure 54 shows that the most successful projects had a well-documented plan in place.

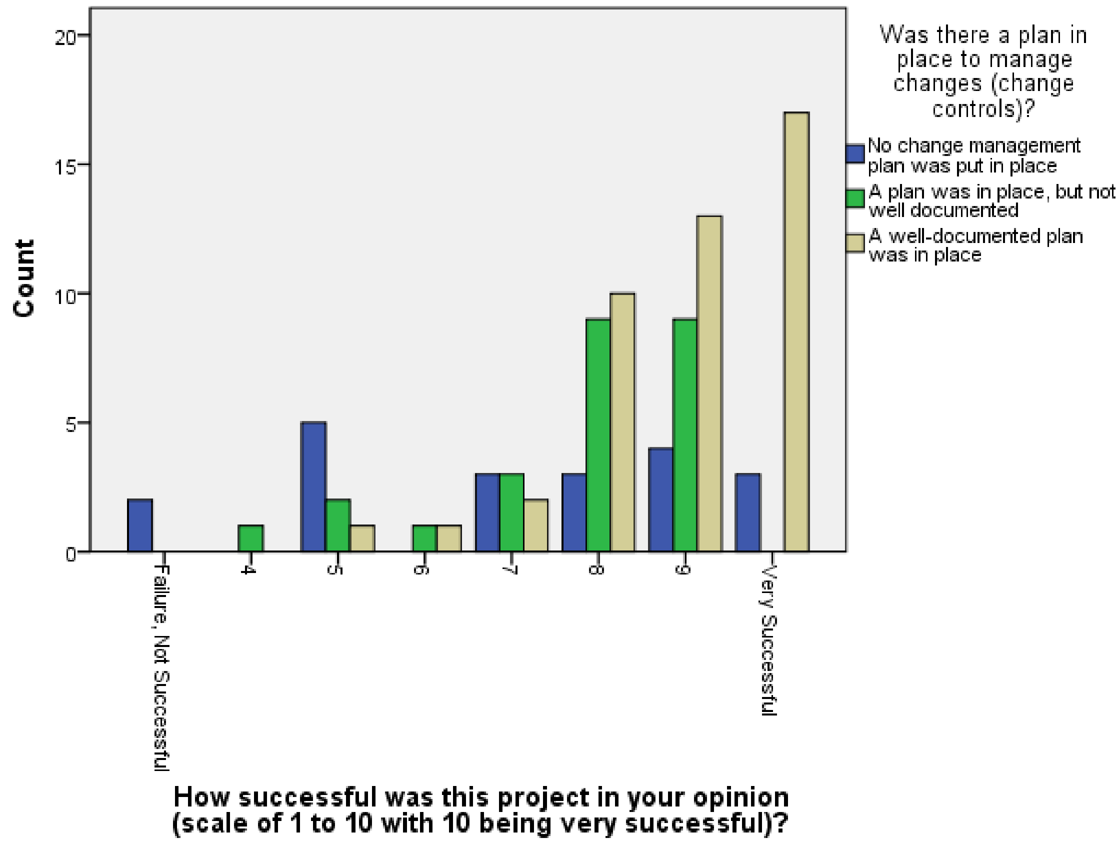

Figure 54 Project Success Rates Compared to Changes Request Plans

Table 105 shows the data with project ratings of 8, 9, or 10 categorized as successful and all others as failures.

Table 105 Project Success Compared to Presence of Change Management Plan

		Projects rated as successful with 8, 9, or 10 were considered successful.		
		Successful	Failure	Total
Was there a plan in place to manage changes (change controls)?	No change management plan was put in place	10	10	20
	A plan was in place, but not well documented	18	7	25
	A well-documented plan was in place	40	4	44
Total		68	21	89

Analyzing the data for statistical significance shows that a χ^2 value of 9.210 would be needed to reject the null hypothesis with 99% confidence. The χ^2 value for these data is 13.138 which more than enough for 99% confidence. A change management plan directly impacts project success. Table 106 shows the results of the chi-square analysis.

Table 106 Testing Null Hypothesis of Project Success Compared to Change Management Plan

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	13.138[a]	2	.001
Likelihood Ratio	13.073	2	.001
Linear-by-Linear Association	12.968	1	.000
N of Valid Cases	89		

a. 1 cells (16.7%) have expected count less than 5. The minimum expected count is 4.72.

<u>PM19 / RE22: How satisfied was the customer with the final deliverable (scale of 1 to 10 with 10 being very satisfied)?</u>

Customer satisfaction is a gauge of quality of the project. This is an indicator as to whether the scope was met. 39.3% of customers were very satisfied with the final deliverables. Of all projects, 75.3% had a customer satisfaction rating of 8, 9, or 10. Of projects with a success rating of 8, 9, or 10, 94.1% had a customer satisfaction rating of 8, 9, or 10. Of projects with a success rating of 8, 9, or 10, 71.9% had a customer satisfaction rating of 9 or 10. This indicates that those projects that were marked as most successful had satisfied customers and therefore the success rating is valid for this measure. Table 107 compares project success rating to the customer satisfaction rating.

Table 107 Project Success Rates Compared to Customer Satisfaction Rates

		How satisfied was the customer with the final deliverable?										
		Dissatisfied	2	3	4	5	6	7	8	9	Very Satisfied	Total
How successful was this project in your opinion (scale of 1 to 10 with 10 being very successful)?	Failure, Not Successful	1	1	0	0	0	0	0	0	0	0	2
	4	0	0	1	0	0	0	0	0	0	0	1
	5	1	0	0	0	6	0	0	0	0	1	8
	6	0	0	0	0	1	1	0	0	0	0	2
	7	0	0	0	1	0	1	4	2	0	0	8
	8	0	0	0	0	0	1	3	11	7	0	22
	9	0	0	0	0	0	0	0	4	13	9	26
	Very Successful	0	0	0	0	0	0	0	2	3	15	20
Total		2	1	1	1	7	3	7	19	23	25	89

Figure 55 shows there may be a correlation between customer satisfaction and project success. The greatest number of "Very Satisfied" or 10 ratings in customer satisfaction were placed on projects which also had an overall success rating of 10. This is also true for customer ratings and project success ratings of 7, 8, and 9.

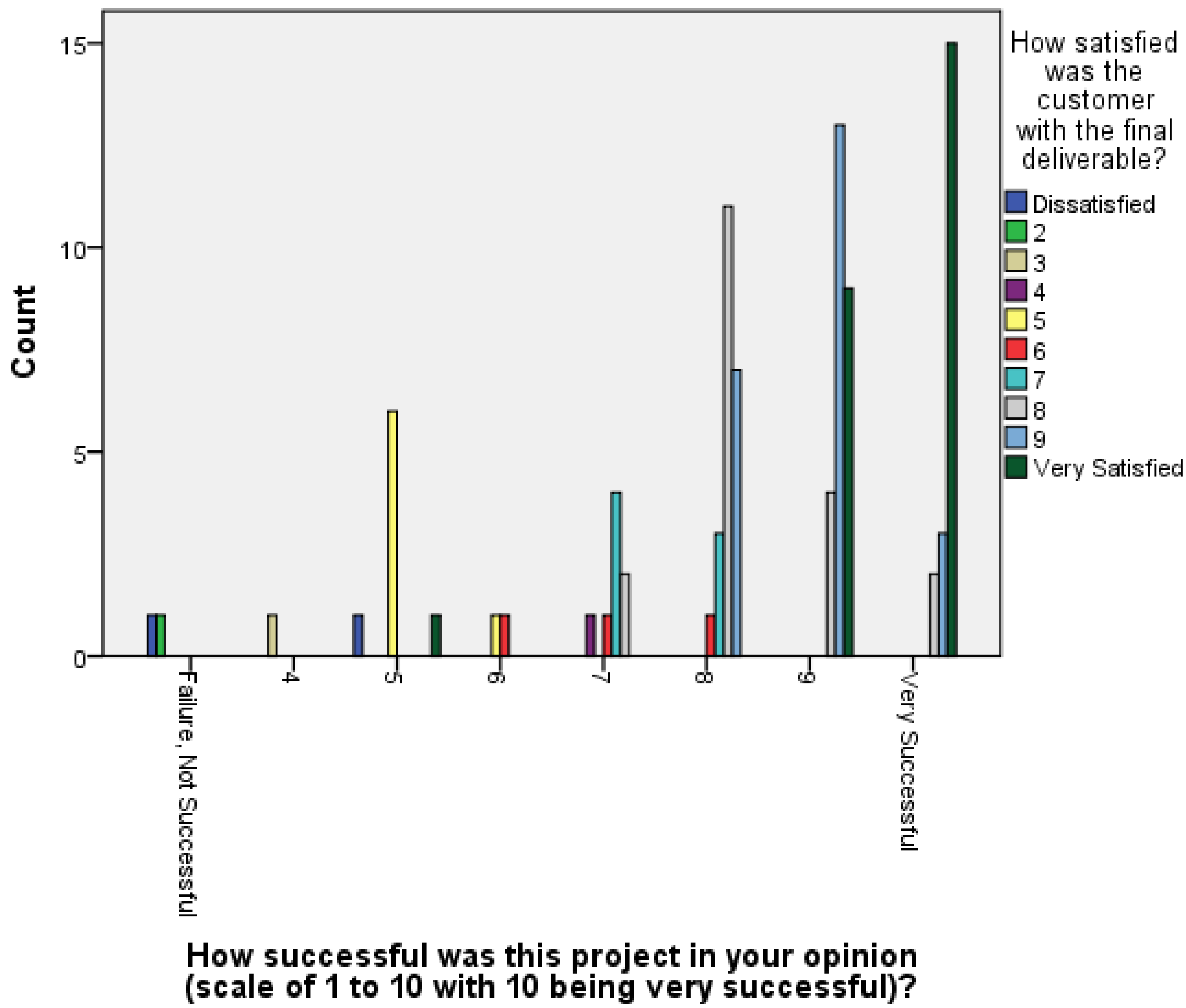

Figure 55 Project Success Rates Compared to Customer Satisfaction Rates

Table 108 shows the data with project ratings of 8, 9, or 10 categorized as successful and all others categorized as failures.

Table 108 Project Success Compared to Customer Satisfaction With Deliverables

		Projects rated as successful with 8, 9, or 10 were considered successful.		
		Successful	Failure	Total
How satisfied was the customer with the final deliverable?	Dissatisfied	0	2	2
	2	0	1	1
	3	0	1	1
	4	0	1	1
	5	0	7	7
	6	1	2	3
	7	3	4	7
	8	17	2	19
	9	23	0	23
	Very Satisfied	24	1	25
Total		68	21	89

This data can be analyzed for statistical significance. A χ^2 value of 27.877 would be needed to reject the null hypothesis with 99.9% confidence. This data yielded a χ^2 value of 60.542. This means that customer satisfaction with the deliverables directly impacts project success. Table 109 shows the results of the chi-square analysis.

Table 109 Test of Null Hypothesis Comparing Project Success and Customer Satisfaction With Deliverables

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	60.542[a]	9	.000
Likelihood Ratio	62.690	9	.000
Linear-by-Linear Association	49.303	1	.000
N of Valid Cases	89		

a. 13 cells (65.0%) have expected count less than 5. The minimum expected count is .24.

PM20 / RE23: Did the customer use or have plans to use/implement the final deliverable?

Another measure of quality is whether the customer was using or planned to use the final deliverables. If the customer wasn't going to use any of the deliverables, the deliverables may not have been satisfactory. Customers were using or were planning to use the deliverables for 93.3% of the projects. This validates the quality of the deliverables and substantiates the successful rating of the projects. Table 110 shows a comparison of project success rates to whether or not the customer implemented the final deliverables.

Table 110 Project Success Rates Compared to Customer Implementation

		Did the customer use or have plans to use/implement the final deliverable?			
		Yes	No	Don't Know	Total
How successful was this project in your opinion (scale of 1 to 10 with 10 being very successful)?	Failure, Not Successful	0	0	2	2
	4	1	0	0	1
	5	7	1	0	8
	6	2	0	0	2
	7	8	0	0	8
	8	21	1	0	22
	9	25	0	1	26
	Very Successful	19	1	0	20
Total		83	3	3	89

Figure 56 shows that more successful projects tend to have customers who are using or planning to use the final deliverables.

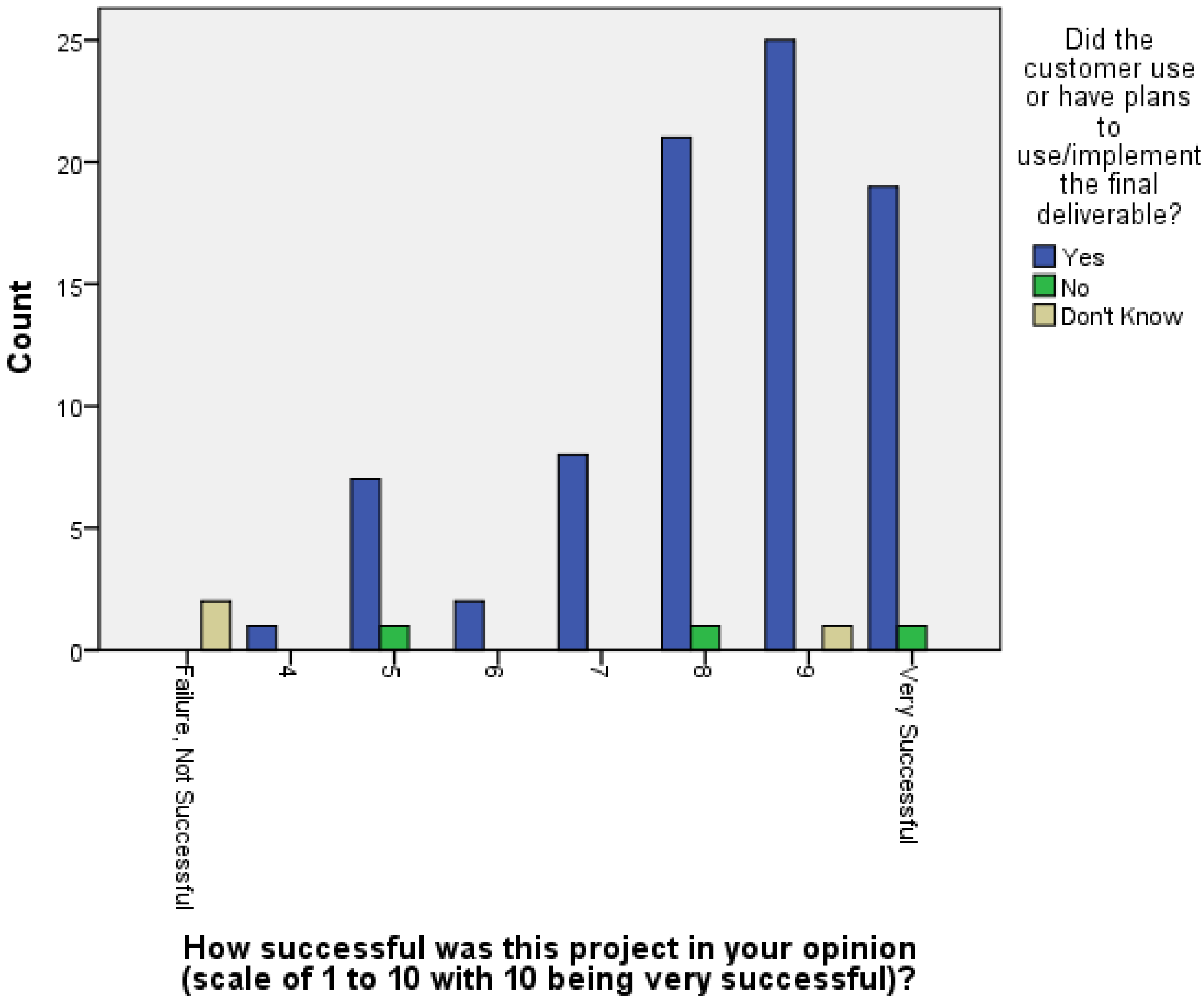

Figure 56 Project Success Rates compared to Customer Implementation

Table 111 shows the data with project ratings of 8, 9, or 10 categorized as successful and all others categorized as failures.

Table 111 Project Success Compared to Customer Implementation

		Projects rated as successful with 8, 9, or 10 were considered successful.		
		Successful	Failure	Total
Did the customer use or have plans to use/implement the final deliverable?	Yes	65	18	83
	No	2	1	3
	Don't Know	1	2	3
Total		68	21	89

Analyzing this data for statistical significance shows that a χ^2 value of 5.991 would be needed to reject the null hypothesis with 95% confidence. A χ^2 value of 3.219 would be needed to reject the hypothesis with 80% confidence. The χ^2 value for this data is enough to reject with 80% confidence, but not 95% confidence. A plan to use or implement deliverables does not impact project success. Table 112 provides the results of the chi-square analysis.

Table 112 Test of Null Hypothesis of Project Success Compared to Customer Implementation

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.413[a]	2	.182
Likelihood Ratio	2.812	2	.245
Linear-by-Linear Association	3.221	1	.073
N of Valid Cases	89		

a. 4 cells (66.7%) have expected count less than 5. The minimum expected count is .71.

<u>PM21 / RE24: Was the customer's organization or culture positively impacted by the final deliverable(s)? For example, would the final deliverable(s) help the customer meet a strategic goal?</u>

A positive impact to the customer's organization is another measure of quality for a project. If the deliverable did not have a positive impact, the deliverables may not have been needed by the customer or some requirements may not have been met. Among projects, 86.5% provided a positive impact to the customer's organization. Of projects with a success rating of 8, 9, or 10, 89.75% did positively impact the customer's organization. This indicates that those projects that were marked as most successful did positively impact the customer's organization and therefore the success rating is valid for this measure. Table 113 shows a comparison of project success rating to the project impact on the organization.

Table 113 Project Success Rates Compared to Impact on the Organization

		Was the customer's organization or culture positively impacted by the final deliverable? For example, would the final deliverable help the customer to meet a strategic goal?			
		Yes	No	Don't Know	Total
How successful was this project in your opinion (scale of 1 to 10 with 10 being very successful)?	Failure, Not Successful	1	0	1	2
	4	1	0	0	1
	5	5	2	1	8
	6	2	0	0	2
	7	7	1	0	8
	8	21	1	0	22
	9	23	0	3	26
	Very Successful	17	1	2	20
Total		77	5	7	89

Figure 57 shows that more successful projects were the ones that positively impacted the customer's organization.

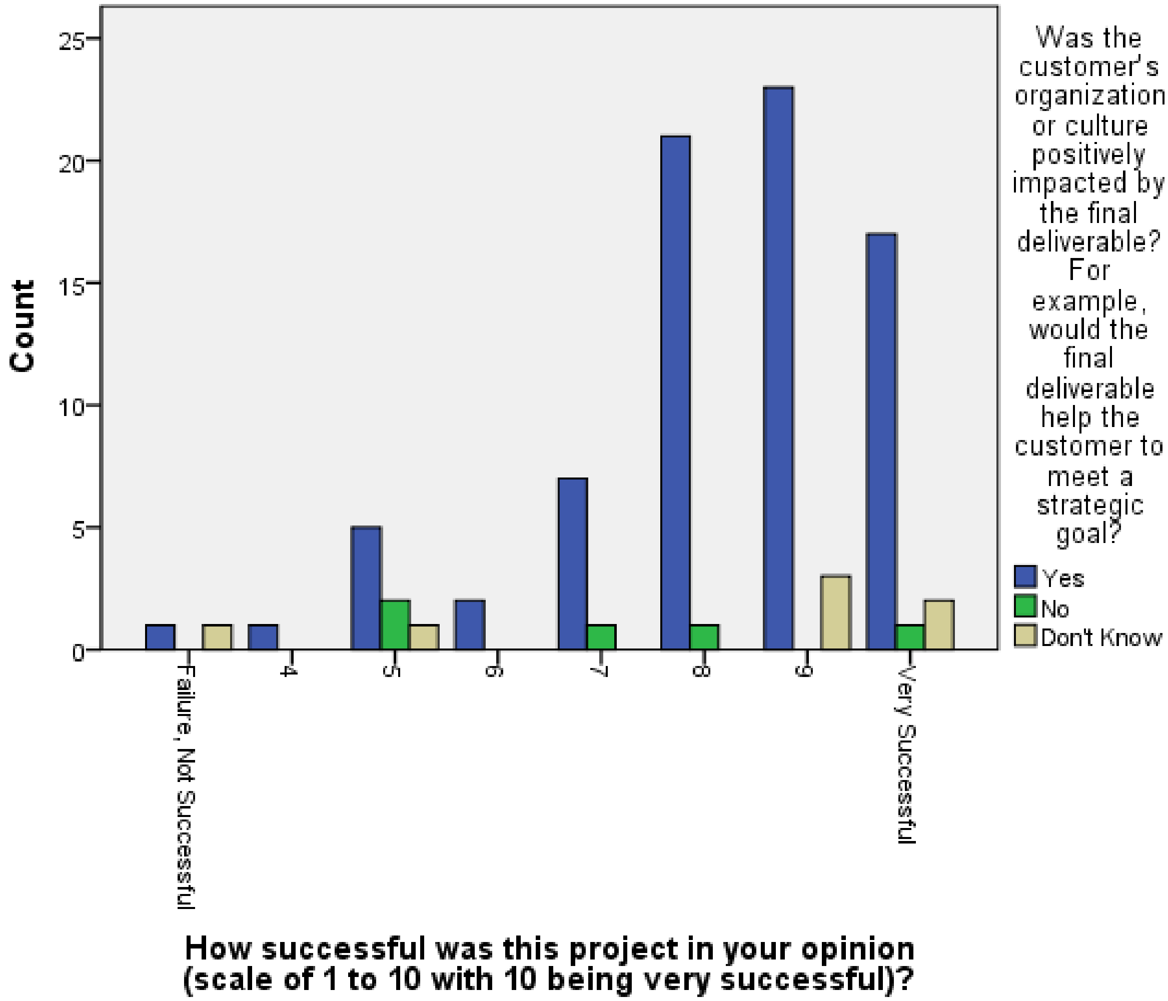

Figure 57 Project Success Rates Compared to Impact on the Organization

Table 114 shows the data with project ratings of 8, 9, or 10 categorized as successful and all others as failures.

Table 114 Project Success Compared to Organizational Impact

		Projects rated as successful with 8, 9, or 10 were considered successful.		
		Successful	Failure	Total
Was the customer's organization or culture positively impacted by the final deliverable? For example, would the final deliverable help the customer to meet a strategic goal?	Yes	61	16	77
	No	2	3	5
	Don't Know	5	2	7
Total		68	21	89

This data can be analyzed for statistical significance. A value of 5.991 would be needed to reject the null hypothesis with 95% confidence. The value from these data is 4.111. The null hypothesis cannot be rejected. Deliverables having a positive impact on the customer's organization do not impact project success. Table 115 provides the results of the chi-square analysis.

Table 115 Test of Null Hypothesis of Project Success Compared to Organizational Impact

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.111[a]	2	.128
Likelihood Ratio	3.452	2	.178
Linear-by-Linear Association	1.200	1	.273
N of Valid Cases	89		

a. 3 cells (50.0%) have expected count less than 5. The minimum expected count is 1.18.

SUMMARY

Based on the responses, completing a project with the planned amount of effort determines project success. The scope for the project must also be defined for the project to be successful. This scope must be met for the project to be successful. A change management plan must be established for a project to be successful. The customer must also be satisfied with the final deliverables for the project to be successful. Finishing the project on time or within budget did not impact project success. Whether or not the customer had a plan to implement the final deliverables also did not impact project success. It also did not impact project success whether or not the customer's organization was positively impacted by the final deliverables. The scope of the project cannot be defined without good requirements. There is also no possibility of meeting scope without good requirements. Both of these underline why requirements are important to a project and a project cannot succeed without good requirements.

VITA

CYNTHIA D. ATKINS

Personal Data:	Date of Birth: December 3, 1975
	Place of Birth: Johnson City, Tennessee
	Marital Status: Married
Education:	M.S. Computer and Information Science, East Tennessee State University, Johnson City, Tennessee 2013
	B.S. Computer and Information Sciences, East Tennessee State University, Johnson City, Tennessee 1998
	Public Schools, Johnson City, Tennessee
Professional Experience:	Program Manager, Eastman Chemical, Kingsport, Tennessee, 2008-Present
	Project Manager, Scripps Networks, Knoxville, Tennessee, 2003-2007
	Database Administrator, New Ideas Computer Consulting, Knoxville, Tennessee, 2001-2002
	Software Engineer, Duley, Hopkins, and Associates, Oak Ridge, Tennessee, 2001-2002
Honors and Awards:	Project Management Professional (PMP), 2006